

(ISSN 0892-1016)

THE
JOURNAL
OF
RAPTOR RESEARCH



VOLUME 25

FALL 1991

NUMBER 3

CONTENTS

HUNTING RANGE AND STRATEGIES IN A TUNDRA BREEDING PEREGRINE AND GYRFALCON OBSERVED FROM A HELICOPTER. Clayton M. White and R. Wayne Nelson.....	49
BIASES IN DIETS DETERMINED FROM PELLETS AND REMAINS: CORRECTION FACTORS FOR A MAMMAL AND BIRD-EATING RAPTOR. R.E. Simmons, D.M. Avery and G. Avery	63
NEW GOLDEN EAGLE RECORDS FROM BAJA CALIFORNIA. Ricardo Rodríguez- Estrella, Jorge Llinas-Gutiérrez and Jorge Cancino	68
SURVIVAL AND MOVEMENTS OF RELEASED REHABILITATED BALD EAGLES. Mark Martell, Patrick Redig, Jill Nibe, Gail Buhl and Daniel Frenzel	72
FORAGING HABITS, HUNTING AND BREEDING SUCCESS OF LANNER FALCONS (<i>FALCO BIARMICUS</i>) IN ISRAEL. Reuven Yosef.....	77
DO MIGRANT SWAINSON'S HAWKS FAST <i>EN ROUTE</i> TO ARGENTINA? John S. Kirkley	82
SHORT COMMUNICATIONS	
RESPONSE TO KIRKLEY. David L. Goldstein and Neal G. Smith	87
THREE POSSIBLE NEST-RELIEF FACTORS IN THE AMERICAN KESTREL. Juan Esteban Martínez- Gómez	88
INFLUENCE ON PELLET EGESTION TIME IN INDIVIDUAL GREAT HORNED OWLS ALLOWED TO VIEW EGESTION IN OTHER OWLS. Gary E. Duke, Oral A. Evanson and Susan B. Chaplin	90
DIURNAL BODY TEMPERATURE CYCLE IN THE NORTHERN HAWK-OWL. Charles T. Collins	92
JUVENILE URBAN-HACKED PEREGRINE FALCONS (<i>FALCO PEREGRINUS</i>) HUNT AT NIGHT. Annie Wendt, Greg Septon and Jeff Moline	94
LETTERS	96
THESIS ABSTRACTS	98
NEWS AND REVIEWS	99

The Raptor Research Foundation, Inc. gratefully acknowledges a grant and logistical support provided by the University of Saskatchewan to assist in the publication of the journal.

Persons interested in predatory birds are invited to join The Raptor Research Foundation, Inc. Send requests for information concerning membership, subscriptions, special publications, or change of address to Jim Fitzpatrick, Treasurer, 12805 St. Croix Trail, Hastings, Minnesota 55033, U.S.A.

The Journal of Raptor Research (ISSN 0892-1016) is published quarterly for \$18.00 per year by The Raptor Research Foundation, Inc., 12805 St. Croix Trail, Hastings, Minnesota 55033, U.S.A. Add \$2 for destinations outside of the continental United States. Second class postage paid at Hastings, Minnesota, and additional mailing offices. Printed by Allen Press, Inc., Lawrence, Kansas, U.S.A.

Copyright 1991 by The Raptor Research Foundation, Inc. Printed in U.S.A.

THIS PUBLICATION IS PRINTED ON ACID-FREE PAPER.

THE JOURNAL OF RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 25

FALL 1991

No. 3

J. Raptor Res. 25(3):49–62
© 1991 The Raptor Research Foundation, Inc.

HUNTING RANGE AND STRATEGIES IN A TUNDRA BREEDING PEREGRINE AND GYRFALCON OBSERVED FROM A HELICOPTER

CLAYTON M. WHITE

Department of Zoology, Brigham Young University, Provo, UT 84602

R. WAYNE NELSON

4218-63rd Street, Camrose, AB, Canada T4V 2W2

ABSTRACT.—Between 6–15 June 1974 an adult male Peregrine Falcon (*Falco peregrinus*) from a breeding site on Alaska's North Slope was followed by helicopter and mapped during 21 hunting sorties. His hunting range was about 319 km² and the greatest straight line distance from the eyrie where he stooped at prey was 14.6 km. All parts of the hunting range were not used equally. An area with sedge-grass marshes and many small lakes was hunted most frequently with 51% of the prey capture attempts occurring there. A second area of similar but drier habitat was used secondly with 36% of prey capture attempts occurring there. Three different hunting methods were used: 1) low, “ground-effect” flight, 2) high direct/maneuvering flight, and 3) soaring. One flight of long duration and one of short duration from start to finish are described. Seventeen hunts timed from leaving to returning to the eyrie averaged 57 min. The shortest hunting sortie followed by helicopter was 22 min; when not followed, the shortest sortie was 23 min. From 2–24 stoops were required during a hunting foray before a kill was made.

Between 27 June and 4 July 1978 near the Dempster Highway, Yukon Territory, Canada, a nesting female Gyrfalcon (*F. rusticolus*) was followed by helicopter (on 9 flights) for a total of 4 hr 1 min and a male (on 5 flights) for 3 hr 10 min. The female hunted and patrolled within 3.2 km of the eyrie. The male went up to 24 km from the eyrie while hunting. On 1 sortie he “patrolled” a three-quarter circle, traveling high approximately mid-way between his eyrie and those of four neighboring pairs. Hunting methods are described and included soaring, ridge-sailing, and “forest slalom.”

We also discussed cautions and advantages of using the helicopter to study home ranges, habitat use and behavior far from the nest.

Área y estrategias de caza de un Halcón Peregrino y Gerifaltes de la tundra observadas desde un helicóptero

EXTRACTO.—Entre el 6 y el 15 de junio de 1974, seguimos en helicóptero a un ejemplar macho adulto de Halcón Peregrino (*Falco peregrinus*) desde su nido en la vertiente norte de Alaska, y describimos su recorrido durante 21 excusiones de caza. Su área de acción cubrió 319 kms². La mayor distancia entre su nido y el punto en que se lanzó en picada para atrapar a la presa alcanzó 14.6 kms. El halcón no usó indistintamente todas las secciones del área, sino que mostró preferencia por un área pantanosa y lacustre. Un 51% de sus lances ocurrieron en el área mencionada. La segunda preferencia resultó ser un área con un hábitat similar, aunque más seco, escenario de un 36% de los lances. El halcón utilizó tres métodos diferentes de caza: 1) vuelo rasante; 2) vuelo, maniobras y suspensión en altura; y 3) planeo de altura. Se describen dos vuelos completos, uno de larga y uno de corta duración. El tiempo de duración de 17 excusiones, desde la salida hasta la llegada, promedió los 57 minutos. Las salidas que seguimos con el helicóptero duraron un mínimo de 22 minutos; las salidas que hizo solo, duraron un mínimo de 23 minutos. Durante las excusiones, el halcón se lanzó en picada entre 2 y 24 veces hasta matar una presa.

Entre el 27 de junio y el 4 de julio de 1978, en las proximidades de la carretera Dempster (Territorio de Yukón) seguimos en helicóptero a una hembra de Gerifalte (*F. rusticolus*) que estaba incubando. La seguimos en 9 vuelos por un total de 4 horas 1 minuto, y a un macho lo seguimos en 5 vuelos por

3 horas 10 minutos. La hembra cazó y patrulló en un radio de 3.2 kms. desde el nido. El macho se alejó, en sus cacerías, hasta 24 kms. del nido. En una excursión realizó un "patrullaje de altura" recorriendo tres cuartas partes de un círculo entre su propio nido y los de 4 vecinos. Se incluyen y se describen tres métodos de caza: planeo de altura, aprovechamiento de corriente de aire ascendente, y vuelo zigzagueante entre los árboles ('slalom').

También se comentan las ventajas y desventajas de usar un helicóptero para estudiar los territorios, el uso de hábitat y el comportamiento de los halcones cuando están lejos del nido.

[Traducción de Hugo N. Olaiz]

There are few published data on hunting ranges of the Peregrine Falcon (*Falco peregrinus*), other than some informative radio tracking studies such as those of Enderson and Kirven (1983), and Mearns (1985). For the Gyrfalcon (*Falco rusticolus*) there are no comparable published data. Much of the information on hunting techniques used by wild falcons comes from observations on the outcome of specific stoops fortuitously observed from the ground (e.g., Rudebeck 1951, Campbell 1975, and Dekker 1987) or from observation of nesting falcons that hunted within sight of nesting cliffs (e.g., Monneret 1973, Bird and Aubry 1982). Because our study sites were selected on the basis of eyrie location relative to intensity of human activities (peregrine) and relative to neighboring eyries (Gyrfalcons) and because it was necessary to know the travels and space use by these wide-ranging falcons, the logistics and problems of using radiotelemetry or ground-based observations precluded those methods. This paper reports on the first successful attempts to study hunting behavior and use of home range of two raptors by following them in a helicopter at close quarters from the birds' leaving their eyrie's to their return.

We recognize that the single pair of both species watched may not be representative of their respective species in tundra habitat. We have tried not to draw too many general conclusions from our observations. Because emotion regarding raptors frequently runs high, a good deal of prudence and common sense must be used when studying them (cf. Fyfe and Olendorff 1976). Although helicopters are routinely used to locate raptor eyries, use of helicopters near eyries is still controversial, especially around rarer species. Our studies provide further information on the responses of 2 raptor species to "non-threatening" helicopters nearby.

The peregrine study (by C.M.W.) was accomplished during the construction of the Alaska oil pipeline on Alaska's North Slope. The study was designed by the U.S. Fish and Wildlife Service and oil company personnel to determine effects of oil development on hunting ranges of the peregrine. The

Gyrfalcon study (by R.W.N.) sought information on hunting methods and ranges relative to neighboring eyries, while gathering population, reproductive, and behavioral data for a subsequent larger study by N. Barichello. White was at first skeptical that a helicopter could be used to follow hunting peregrine but the techniques that evolved proved to be perhaps the most suitable available for this type of study at the time. White's success with peregrines stimulated Nelson to attempt similar observations on Gyrfalcons when that opportunity arose.

STUDY AREA AND METHODS

In this paper a hunt, foray or sortie is defined as a flight in which prey capture appeared to be the main objective. A hunting foray may include any number of stoops or capture attempts of prey. A stoop is any dive during a hunting foray that appears to be directed toward a prey item. A chase is the following, in direct flapping flight, of a prey item with apparent intent to capture.

Peregrine Falcons. Peregrine observations were made on the Sagavanirktok River on Alaska's North Slope from 6–15 June 1974, variously between 0600–2300 H, at one eyrie ca. 3.2 km from an Alaskan pipeline construction camp of about 200 persons. A Bell 206B Jet Ranger helicopter was used to follow the falcon. Originally the helicopter was parked below the eyrie and some 180 m distant. The male falcon, doing all the hunting for the female and recently hatched young, was watched with binoculars from the waiting helicopter until he left the cliff to hunt. The helicopter was then started. Because of a warm-up time for the aircraft, the falcon usually was out of sight and unlocatable by the time we were airborne. We then tried waiting on top of the cliff and some 180 m away hoping to be able to keep track of him as he flew away. This was also unsuccessful.

Upon arrival at the cliff on 7 June after a refueling stop, we intercepted the falcon as he left to hunt. It became evident that once both helicopter and falcon were in the air it was relatively easy to follow him at a distance of 150 m as long as he was silhouetted above the horizon. At that distance, however, he was lost to view as he made his second stoop. In general, once he was lost to vision and if his direction of flight was unknown, he was impossible to relocate except by chance. Because of this problem we adjusted our distance from the airborne falcon until it became clear that he could be followed from as close as 45 m.

While waiting below the eyrie we timed the male's rest intervals between hunting sorties, which were about 1.5

hr. By waiting for this time period and then flying slowly past the roosting male, we found we could flush him into the air, veer away to let him start a hunting trip, and then close the distance and follow him through the entire hunt.

It requires practice and skill on the part of the helicopter pilot to "stoop" along with the falcon, keep it in view and at the same time not put the helicopter into the ground; we were successful in following the stoop from start to finish and the hunt from start to finish in most cases.

The size of the home range was determined by plotting movements of the male on a 1:63 360 scale (contour interval 15 m) U.S. Geological Survey map. Stoops he executed were marked on the map. Drawing lines around the hunting range is at best approximate, and we chose to use the boundary lines of the 1 mi² (2.5 km²) sections or half sections diagonally on the map. Locations of the dots indicate the nature and extent of the hunting range. Events were timed with the helicopter clock and notes were made as events occurred. Air speeds given were those registered on the helicopter air speed indicator.

Gyrfalcons. One pair, caring for well-feathered nestlings and then just-flying fledglings, was studied about 10 km from the Dempster Highway, Yukon Territory, Canada. A Bell 206A Jet Ranger helicopter was used. Observations were made between 0900–1800 H, on 6 d from 27 June to 4 July 1978. Helicopter-sharing and logistics precluded observations (a) early in the day, (b) for long durations during any one day, and (c) earlier in the nestling phase. We followed the falcons for just over 7 hr but spent 29.6 hr on the ground observing the nest and environs, awaiting the movement of the adult female off the cliff or the arrival back of either adult. There was no predictability to the timing of the hunts of these falcons. Presence of the male usually was fleeting. He quickly delivered prey to the female or nestlings and immediately left the vicinity of the eyrie. Sometimes we waited up to 5 hr before an adult became visible and available for "shadowing." We were aware of White's success with waiting 1.5 hr before "bumping" the male peregrine into flight, and then following on a hunt. This procedure did not work with Gyrfalcons. The male usually did not perch near the cliff nor begin his hunts from there, and the female, if "bumped," usually simply flew to another perch.

When we arrived near the nest cliff we flew slowly along a ridge running west from the cliff, attempting to find a falcon "ridge sailing," whereupon we followed the bird; or after finding one perched on a prominent rock. If no bird was located, we parked the helicopter on a "bench" slightly below the nest elevation and about 300 m in front of the cliff, to await an opportunity to follow a bird. After some early frustrations at losing sight of adult birds while the helicopter warmed up, we used every opportunity to follow the female as she flew and soared in the general vicinity of the nest cliff. Several times this allowed us to find the male when the female broke off soaring and flew 1 km or more from the nest cliff to receive an aerial food transfer of prey from the male.

Twice, while flying steeply upward toward a high-soaring Gyrfalcon, the helicopter stimulated a stoop from the falcon directly toward the aircraft. Once the falcon pulled out only 10–15 m over the rotors. The other time the helicopter turned aside and fled and the falcon's actions

went unrecorded. Flying the helicopter upward 200–300 m from the falcon, and then slowly approaching it horizontally, caused neither attack nor avoidance.

Usually we followed 30–50 m behind with the falcon at the 1000–1030 H position. If we were directly behind, the falcon often glanced back over its wing, indicating some concern. A position slightly below the falcon allowed for easier viewing of the bird above the horizon. When the bird soared, we often followed it on the opposite side of the circle or hovered just outside its soaring circle. Flight routes of the falcons were plotted on a 1:250 000 National Topographic Series map (150 m contours) and detailed notes made during the flights.

RESULTS AND DISCUSSION

Peregrine Hunting Range: Size. The hunting range was approximately 319.8 km² based on 19 hr 20 min that the male was followed (Fig. 1). The greatest straight line distance from the eyrie where a stoop was made was 14.6 km to the SE. Actual size of the hunting or home range has not been determined for other pairs of tundra inhabiting peregrines, so far as we are aware. Even in relatively uniform tundra habitat, size of the hunting range may vary considerably from individual to individual as shown for the Prairie Falcon (*F. mexicanus*; U.S. Dept. Interior 1979) in a relatively homogeneous sagebrush habitat.

Information on home range size of peregrines elsewhere suggests similar extreme distances traveled from the eyrie and some have ranges a fraction of the size of the Alaskan male. A male and female in California were radio-tracked to about 8 km from their eyrie while a female in Colorado was tracked as far as 19 km from her eyrie (Enderson and Kirven 1983). Of two telemetered females in Scotland followed late in the breeding season, one ranged as far as 18 km from her eyrie, and the two females had maximum hunting ranges of 23 km² and 117 km², respectively (Mearns 1985). Also, in Scotland, Weir (1978, not using telemetry) found no evidence of prey being taken more than 6 km from an eyrie. In that study about 60%, by weight, of the food was grouse (*Lagopus* sp.). In Utah, peregrines have traveled 19–24 km from the eyrie to favored feeding localities (White 1963, Porter and White 1973).

Peregrine Hunting Range: Use. Different regions and habitats around the eyrie were hunted with different intensity. This was probably related in some fashion to prey density and vulnerability (see also Schoener 1971). Wet tussock-heath tundra areas with numerous lakes and sedge-grass marshes in the quarter of the hunting range SE of the eyrie received

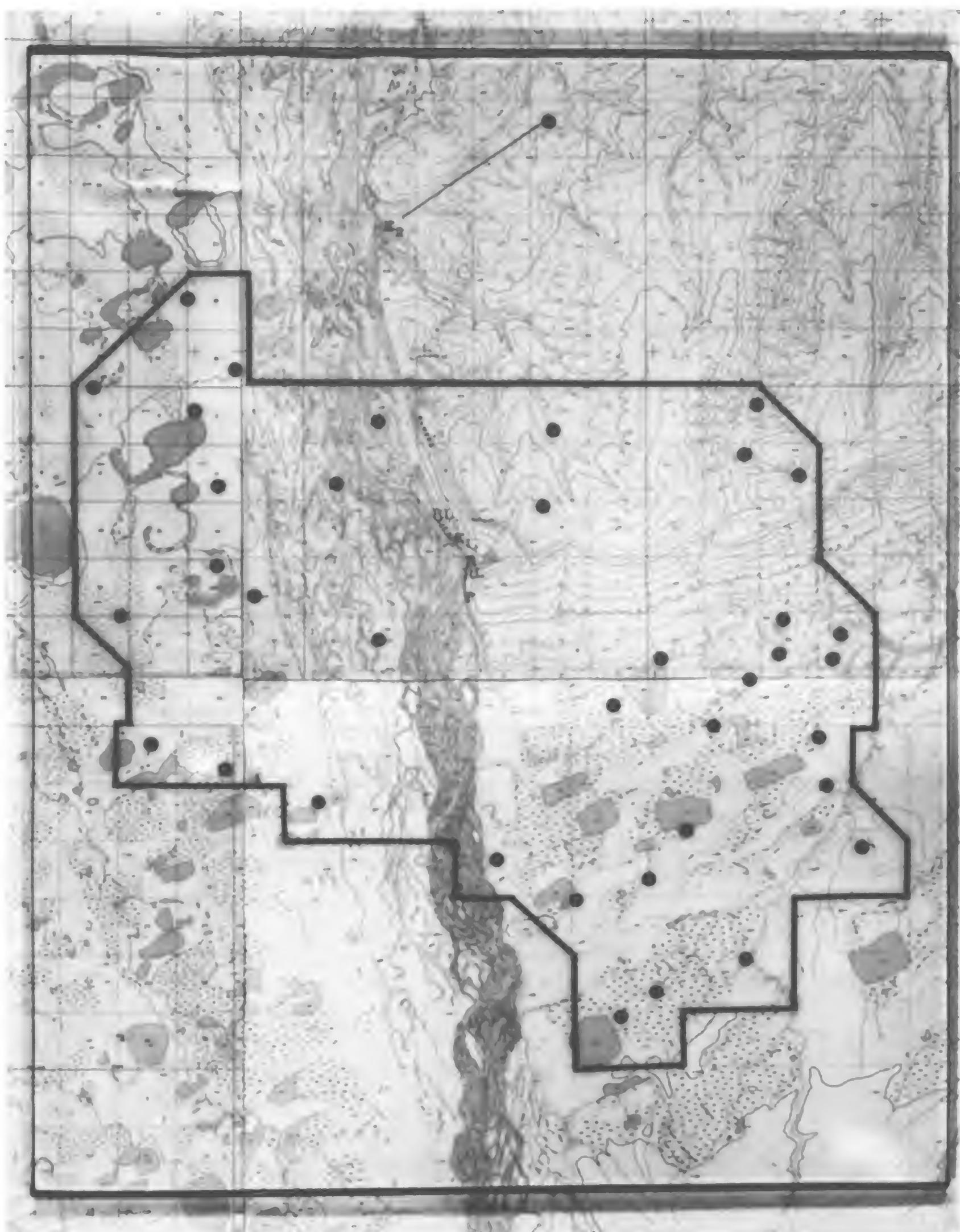




Figure 2. View from near eyrie 2 (see E2, Fig. 1) on 12 June showing the river valley in the midground and wet tussock-heath tundra with numerous lakes in the background.

greatest use (Fig. 2). Fifty-one percent (counting those where we started to follow him but then subsequently lost him) of the hunting forays occurred over this area. Likewise, the greatest amount of time was spent by the male in that area and he went farthest from the eyrie in that direction. West across the river an area of similar habitat but much drier and better drained received the next greatest use. About 36% of the hunting sorties occurred there.

The least used areas were the river corridor and the quarter of the hunting range E, overland from the eyrie. That overland habitat was an elevated region of extremely dry tussock-heath tundra with several willow fringed streams draining S into the wet tundra. Only 13% of prey capture attempts occurred there and most were along a stream rather than over the tussock-tundra itself, although the falcon did crisscross the tundra.

←

Figure 1. Approximate hunting range (within black lines, see text for discussion) of a breeding male Peregrine Falcon in tundra environment. Top of figure is north. Squares on map = 1 mi². Dots represent locations of stoops or chases after prey, selected to avoid clutter and to indicate nature and area of hunting range. E2 outside the hunting range is a second peregrine eyrie and shows one location where the female from that eyrie was followed and stooped at prey. Within the hunting range from top to bottom are a cluster of raptor nests; RL = Rough-legged Hawk (*Buteo lagopus*) nest, E1 = peregrine eyrie from where male was followed, R = Common Raven (*Corvus corax*), RL = a second Rough-legged Hawk, and P = territory held by a lone female peregrine.

Although experience elsewhere on the North Slope indicated that riparian habitat along the rivers received considerable hunting pressure, this was not the case on the Sagavanirkok River. On the Colville River, for example, about 17% of 433 bird-prey items (12 of 41 prey species) consisted of willow-inhabiting passerines typical of riparian habitat (White and Cade 1971). Unlike the Colville, willows along the Sagavanirkok River were generally small and less dense and appeared to support considerably fewer birds. Only three stoops were seen over the main river.

Gyrfalcon: Hunting Range: Size. We flew with the female on nine occasions, totalling 4 hr 1 min, with the longest single flight lasting 63 min and consisting of much high soaring. Six attacks at prey were observed, and one Arctic Ground Squirrel (*Spermophilus parryi*) was captured. When at a perch, soaring at 600 m, or drifting on the wind up and down the high ridges extending away from the eyrie, she appeared to be hunting. Once she attacked an intruding immature Golden Eagle (*Aquila chrysaetos*). Her activities were all confined to within 3.2 km of the eyrie, possibly because of her reluctance to leave with nesting and non-nesting eagles nearby.

We followed the male on five occasions, totalling 3 hr 9.5 min, with the two longest flights lasting 67 and 67.5 min before he was lost to view. One flight was short, to a commanding ridge-top perch, and as we landed nearby, he disappeared off the far side of the rock. One flight went rather directly high and SW over a large tundra plain, another went high and S about 9 km, then W for 8 km to near the same location on the tundra plain. On both flights, by following at too great a distance, we lost him as he suddenly dived steeply and went below the horizon, once at about 600 m and once at about 900 m above ground level. The fourth flight went high and N for 10 km to a mountain range where he hunted the ridge tops and near the peaks at over 1525 m; at one point he was 24 km from the eyrie. We lost him as he crossed over a mountain ridge and disappeared down into a huge tundra-clad bowl. The fifth flight was long, appeared to not involve hunting until the final minutes, again in the tundra plain about 9 km SW of the eyrie; it is described below.

Other studies have shown that Gyrfalcons range widely to obtain food, especially in years when ptarmigan (*Lagopus* sp.) numbers are low (White and Cade 1971). On Alaska's North Slope they appear

to go in excess of 16 km from the eyrie and Kistchinskii (1958) determined that on the Kola Peninsula Gyrfalcons may travel approximately 19 km from the nest to hunt.

Gyrfalcon Hunting Range: Patrolling. On one flight the male flew high N toward the mountains, passing 8 km E of a neighboring occupied eyrie, then 7.5 km E of another eyrie. At that point he had curved NE and eventually arrived over a bank of low cloud which blanketed the mountain range. He then flew E for about 5 km over the edge of the mountains and cloud until turning S when 6.5 km W of another eyrie. He flapped and glided almost directly south for about 14 km, turning SW when 4.5 km from yet another eyrie. After flying about 10 km SW over the tundra plain, he wandered 5 km NW and began a series of low level hunts. After about 10 km of low-level hunting he landed during a rain shower, and eventually we lost him there, in the general vicinity of where we had lost him on the two stooping flights. The first part of this flight gave every appearance of being a boundary patrol of the line midway between his eyrie and that of four neighboring Gyrfalcon pairs to the WNW, NW, NE, and ESE. (No active eyrie was found in the mountain range to the N of this eyrie.) This flight path described a slightly flattened circle and enclosed almost 200 km². His total observed travels in just over 3 hr of our flight time encompassed about 280 km².

Peregrine Hunting Sorties: Methods. The predominant mode of hunting by peregrines has generally been portrayed as a steep angle stoop from a "waiting-on" position at prey that is already on the wing. Watching peregrines hunt in an array of habitats (tundra, montane, taiga, tropical forest, marine and urban) suggests that certain modes of hunting are used more in one habitat than in another and that several types are used with considerable frequency. Some of the techniques used by the peregrine were similar to those briefly described for Gyrfalcons (White and Weeden 1966, Bengston 1971).

Three distinct hunting strategies were observed in this study: 1) low, maneuvering "ground-effect" flight, 2) high, direct/maneuvering flight, and 3) soaring "waiting-on" flight. These types were used in combination and most frequently the latter two were used alternately. However, soaring was used almost exclusively in the case of one hunting sortie once the male was over the preferred hunting area.

The low, ground-effect flight consisted of continuous, rapid wing beats while traveling on average

60–80 kmph (air speed) about 12–25 cm above the ground. In direct (unladen) flight to hunting areas the male averaged about 55 kmph which is nearly 20% faster than normal cruising air speeds (\bar{x} 44 kmph) of migrating peregrines (Cochran and Applegate 1986). On several occasions during the low ground-effect flights the tips of the wings seemed to actually touch the tops of tussock mounds or the water over which the falcon flew. On one occasion (flight started at 1809 H) he continued this strategy over a zig-zagging course covering about 7 km during which time three passerines flushed in front of him. He unsuccessfully grabbed at each of them. He achieved at least 112 kmph on three occasions. Finally at 1830 H a male Willow Ptarmigan (*L. lagopus*) flushed from the dwarf willows along a stream the falcon began to follow. The falcon was traveling so quickly that he had to make a rather wide arc before he could start chasing the ptarmigan, which had by that time gained about 60 m on the falcon. The falcon took a direct course at the ptarmigan until it was evident that the ptarmigan was turning to fly downhill at which time the falcon took a diagonal course to intercept it. The falcon reached the ptarmigan after about 215 m. Just as he was about to grab the ptarmigan from behind (both birds being about 2 m above the tundra) the latter rose vertically into the air and the falcon passed under him, after which the ptarmigan dropped straight to the ground (a typical ptarmigan evasive tactic to avoid Gyrfalcons as described by White and Weeden 1966). The peregrine made 2 shallow stoops at the ptarmigan on the ground. An immature Golden Eagle that was summering in the immediate area and perhaps had been sitting on the tundra, suddenly flew in at the ptarmigan. The falcon immediately began to soar (1834 H) and reached 80 m where he remained until 1836 H when he stooped at a prey item on the ground, missed, and began the low flight again. At 1840 H he was momentarily lost to view and as we sat the helicopter down we saw him rise above the horizon (perhaps 5 m in the air) in the fashion of a falcon that had missed its prey after a stoop, and he then resumed the low-to-the-ground flight. We were unable to relocate him. He returned to the eyrie with prey at 1936 H.

During the time we were able to follow him he covered about 12–16 km of circuitous flying. He spent at least 22 min of the time traveling less than 30 cm off the ground at about 72 kmph, occasionally exceeding 112 kmph, with a continuous wing beat.

The manner in which he followed the contour of the ground at those speeds was similar to behavior we have seen in peregrines following the contours of the ocean's swells as they hunt small alcids and storm-petrels (*Oceanodroma* sp.; cf. Sherrod 1988 for a discussion). Apparently by flying so low, falcons in both environments are gaining the advantage of reduced drag produced by the so-called "ground-effect" described by pilots as lift produced by compression of air below the wing when within one-half the wing span of the ground (cf. Jenkins 1974, Welch 1987) and thereby obtain higher speeds from the same energy expenditure. Such rapid, low-level flight also must be important in approaching and surprising potential prey.

The course of two high, direct/maneuvering hunting sorties, one of long and one of short duration, are given in Tables 1 and 2. One of the more salient features of these sorties was the "all business" attitude of the male when hunting, similar to the high intensity hunting of Treleaven (1980). Immediately after a stoop he climbed directly back to a high position and began searching for another prey item. Note in Table 1 how consistently and quickly he rose to near 150 m after each capture attempt. A consistent height was also regained after each stoop by the peregrines monitored by Alerstam (1987). Even when the falcon struck a potential prey but did not kill it he promptly began hunting again.

The peregrine did not use the cliff as a perch from which to launch directly at prey nor did he make kills near the cliff. Hunting from a cliff perch was seen in the tundras of Greenland (W. Burnham, pers. comm., Harris and Clement 1975) to catch Lapland Longspur (*Calcarius lapponicus*) and Wheatear (*Oenanthe oenanthe*), in the Yukon taiga to chase passerines and shorebirds, and in the marine setting to catch small seabirds (R.W.N., pers. obser.). This method has also been observed in western montane regions (C.M.W., pers. obser.). We likewise did not observe peregrines chase prey high into the air where they are finally caught and killed (Campbell 1975, Cade 1982, Clunie 1976). Both methods, however, probably are used on occasion in the tundra.

More prey items were killed on the ground or grabbed while only a few meters in the air than those "struck" in the air. Careful observations from other regions are similar. Monneret (1973) watched about 400 attacks by a breeding peregrine in mountainous country in France and found that the falcon

Table 1. A long hunting sortie of male peregrine employing both soaring and high flight on Alaska's North Slope, followed on 12 July 1974.

TIME	EVENT	COMMENTS
1125	Started hunt	Left cliff going to SE at 90 m and 56 kmph (helicopter air speed), climbing to 240 m, steady wing beat until arriving over ice-covered lake about 12.8 km SE of eyrie.
1134	Arrive at lake	Continuous, steady wing beat.
1136	Stoop	Missed intended prey, climbed immediately again to 90 m, continuous steady wing beat.
1137	Stoop	Hit sandpiper (<i>Calidris</i> sp.) on ground but could not hold it, chased sandpiper up to about 90 m where he began soaring for first time trying to get above the sandpiper eventually going to 120 m.
1141	Steady wing beat	Altered wing beating with soaring for 2 min, reaching 130 m.
1142	Soaring	Alternated wing beating with soaring maintaining about 130 m.
1143	Stoop	Low across lake, striking water surface twice in attempt at a Red-necked Phalarope.
1145	Climbing	Climbed immediately back up to 150 m with steady wing beat.
1146	Soaring	—
1147	Stoop	Began stoop at 200 m, leveled off horizontal by ca. 10 cm above ground while 180 m from prey and exceeded 160 kmph (air speed) along ground, missed prey, climbed immediately back up to 110 m.
1148	Flight	Began alternating soaring and steady wing beating.
1148.5	Stoop	Hit an American Golden Plover and dragged plover a few feet across ground but lost hold.
1149	Climbing	Climbed back to 90 m.
1149.5	Soaring	Soared up to 220 m.
1150	Alternate flying modes	Between 1150 and 1203 H there was alternating of a steady wing beat followed by a glide and then soaring followed by steady wing beat with a repeat of the sequence; reached 226 m.
1203	Stoop	Missed sandpiper (<i>Calidris</i> sp.) on ground on first try, momentum carried him ca. 5 m in the air where he tried twice more at sandpiper as it flew across tundra.
1203.5	Interspecific encounter	Chased by Parasitic Jeager (<i>Stercorarius parasiticus</i>) briefly but then jeager began chasing the sandpiper.
1204	Climbing-soaring	Climbed back up to 215 m where he soared for 6 min reaching 330 m; defecated twice.
1210	Stoop	Increased speed to 144 kmph, leveled off about 60 cm above ground while yet 30 m from sandpiper (<i>Calidris</i> sp.); missed.
1210.5	Climbing-soaring	Climbed immediately back up to 120 m again, began to alternate soaring, steady wing beating and gliding, rising to 135 m where he remained for about 7 min.
1217	Stoop	Missed prey, then he continued across tundra at 5-6 m as he grabbed at but missed 2 passerines and 1 sandpiper that flushed from tundra in front of him as he flew past, then climbed.
1222	Stoop	Pulled out after 125 m, leveled off, discontinued stoop and soared.
1229	Stoop	A series of loops and nearly vertical stoops at a passerine but missed.

Table 1. Continued.

TIME	EVENT	COMMENTS
1229.5	Climbing— steady flap- ping	Climbed back up to 120 m, steady wing beat for about 3 min.
1232	Stoop	Hit prey on ground, continued to fly with prey back toward eyrie.
1245	Arrived at ey- rie	Returned to eyrie with a Pectoral Sandpiper after 80 min hunt.

seemed to prefer hunting from a high cliff and "binding" to the prey rather than "waiting on" high in the air and striking the prey. Also, he found that attacks were more often initiated when prey were on the ground or perched than when prey were on the wing (see Monneret 1987). This latter tendency was clearly evident with the peregrines on the North Slope.

Most stoops were executed at about a 60°–45° angle (but see Alerstam 1987) reaching speeds of at least 160 kmph with a leveling off at about 60–150 cm in the air while yet 30 m or so from what proved to be his intended prey. Most frequently we could not discern what he was after until we saw it flush or saw him actually strike at it. Several stoops were started over 1.6 km from the point where he actually struck at the prey. The majority of the stoops were made from an altitude of 215–320 m.

Peregrine Hunting Sorties: Duration and Success. The presence of the helicopter seemed not to

alter the duration or success of the falcon's hunting effort. The average length of 17 successful hunting sorties for which we have precise times on departure from the eyrie to return was 57 min (on some of these the falcon was lost so we returned directly to the eyrie to await his arrival). When followed in helicopter ($N = 10$), the shortest time between leaving the eyrie, making a kill and returning to the eyrie was 22 min. When not followed ($N = 7$) the shortest time was 23 min. The longest time for a sortie when followed was 80 min and 93 min when not followed.

We followed the male falcon on 21 sorties although in 4 cases he was lost in as few as 5 min and in 2 cases he was found again after being lost to view for as much as 5 min. We have a fair degree of confidence that on 13 sorties he averaged about 10 stoops (range 2–24) before making a kill. The 2 stoops were directed at a single prey item and the 24 involved attacks at nine different prey items. Dur-

Table 2. A short hunting sortie of a male peregrine as followed on 12 July 1974.

TIME	EVENT	COMMENTS
1642	Started	Left eyrie going back overland over dry tussock hunt tundra.
1644	Steady flapping	Turned south in direction of lakes.
1647	Stoop	Start stoop at 125 m, missed, climbed back to 122 m.
1647.5	Soaring	—
1648	Stoop	Grabbed sandpiper (<i>Calidris</i> sp.) about 3 m above the ground where he nearly stalled out in the air but regained flight (about 10.4 km SE of eyrie) and headed in the direction of the eyrie but a bit south of it.
1649	Flying	Reached 60–90 m in a steady course flying 44–50 kmph until he reached edge of river bluff at which time he was only 9 m above bluff; dropped low along edge of cliff flying straight to eyrie but 1.6 km north along the bluff.
1705	Exchange	Food exchange in air, female flew off to eat and male went to nest; from leaving cliff to kill 6 min elapsed. From departure to return to cliff 23 min elapsed.

ing the course of a hunt involving 14 stoops, two sandpipers were grabbed but released or escaped. This male was not as efficient as that described by Cade (1982; New Jersey marsh) or L. Hays (pers. comm.; Zion Natl. Park) where frequently prey was caught on the first attempt within a few minutes after the falcon left his perch. In more recent years, two different males along the Colville River, Alaska, have been seen to make a kill on the first stoop of a hunt (C.M.W., pers. obser.).

The prey items that were either killed and identified or identified from the helicopter after a stoop was made were: Willow Ptarmigan, Semipalmated Sandpiper (*Calidris pusilla*), Lesser Golden Plover (*Pluvialis dominica*), Pectoral Sandpiper (*Calidris melanotos*), Red-necked Phalarope (*Phalaropus lobatus*), Lapland Longspur, Savannah Sparrow (*Passerulus sandwichensis*), and American Tree Sparrow (*Spizella arborea*).

Gyrfalcon Hunting Sorties: Methods. Gyrfalcons hunted (a) from perches, and while (b) in a harrier-like flight, (c) ridge-sailing, (d) ridge-hopping, (e) swerving among trees in forest (forest slalom), and (f) traveling high with soaring. Both sexes hunted from commanding perches on rocks on high ridges or hills from which a downhill attack could be initiated. We saw no attacks from the immediate vicinity of the eyrie cliff. Several times the female hunted for many minutes almost like a harrier, flapping and sailing slowly along an erratic path 2–20 m over the tundra and fine gravel ridges, apparently in search of ground squirrels.

Ridge-sailing, on days with sufficient wind, was used especially by the female. With few wing beats she sailed at 3–8 m along and back over the windward side of a long, high ridge. Once she suddenly landed on a patch of dirt and caught a ground squirrel. She sailed a short distance farther along the ridge, then swung back along the ridge and dived to the eyrie with the freshly caught prey.

In the mountains the male traveled close to some low peaks and crossed high over intervening valleys. Several times he crossed very low over ridges (ridge-hopping) and suddenly had below him expanses of tundra in which unsuspecting prey might be spotted.

Especially the male used a forest-slalom hunting method in which, from various heights, he made a rapid, shallow swoop ending with a twisting race for 50 m or much more between the middles and tops of the scattered spruce trees on the slopes of draws in the tundra plain. It was not clear whether

he was attempting to ambush prey already sighted or whether he expected unseen or seen prey to flush in front of him as he suddenly approached.

The male used a very strong flapping pattern when climbing in a straight line or circling up quickly, and when traveling high (airspeed 48–56 kmph). Presumably he was hunting most of the time when he was traveling to an area where he was seen to hunt. When about to initiate an attack he might flap with a more leisurely beat, glide and flap, soar, or continue the strong flapping pattern—we had no warning that a serious attack was to begin. He twice started steep dives from great heights, but the rest of those two hunts went unseen. The female often soared high, especially over the edge of the tundra plain. Sometimes she was followed on a long, very shallow stoop from soaring, ending with a rapid glide just above the vegetation for 50 m or more before pulling out of unsuccessful attacks.

Gyrfalcon Hunting Sorties: Problems in Following. It was extremely easy to lose sight of the falcon. If we lagged too far behind, the falcon could disappear against dark talus or vegetation, and if the falcon stooped it became invisible when it passed below the horizon. Once the falcon crossed a mountain ridge, and we were unable to relocate him when we reached the ridge just seconds later. Not once did it appear that the falcon was attempting to lose the helicopter; this would have been relatively easy for the falcon to do, especially when flying at a considerable height.

If we had flown with the Gyrfalcons early in the nestling phase, before the female had seriously resumed hunting, we probably would have had more opportunities to follow the male on hunts because he was much more conspicuous near the cliff at that time.

Observed Responses to Helicopters. We have accumulated nearly 1700 hr (as of 1990) of combined time in helicopters observing or searching for raptors. From such flights we believe that peregrines are particularly tolerant of helicopters even when not on nests (see White and Sherrod 1973, D.H. Ellis, pers. comm.). Gyrfalcons appear to be less tolerant. It is possible that the falcons we observed for this study became habituated to the helicopters quickly as a result of our early and unsuccessful attempts to follow. Once we mastered the techniques, the birds were not visibly intimidated by the rather slow and unthreatening flight characteristics of our flying patterns. Although it is possible that many of

these birds will readily tolerate a helicopter traveling with them, it must be noted that much of the philosophy and methodology which brought us these results are not detailed here; the potential threat of the helicopter-shadowing technique to the lives of the raptors and their broods, and to the lives of the human observers, may be high and must not be taken lightly.

Several times we passed relatively slowly within 20 m over or beside peregrines in both Jet Rangers and Alouette helicopters. On those occasions the falcons' response was to turn their heads and watch us pass. On one occasion in the Aleutian Islands, as we were landing the helicopter at an archeological site near the beach, we noted an immature female peregrine about 6 months old flying along the beach ridge toward us. She landed on a mound at the archeological site (20 m away) just as we were settling the helicopter to the ground. She watched the helicopter as the main rotor stopped turning, and she did not fly until being frightened as one of us stepped into full view from the aircraft. Similarly, the peregrines we observed on the North Slope were unusually tolerant of the helicopter as long as a human was not in view outside of it. Although we have never witnessed a peregrine attack a helicopter, R.W. Fyfe (pers. comm.) observed this on the MacKenzie River, Canada. In the same general area J. Campbell, Jr. (pers. comm.) reported a peregrine attack upon a fixed-wing aircraft.

Gyrfalcons seem somewhat less predictable, perhaps more aggressive. Both sexes calmly soared within 12–15 m of our hovering helicopter (Fig. 3). However, Gyrfalcon on the North Slope and in this study flew rapidly from helicopters traveling at high speeds, while the aircraft is still several hundred m distant (Platt 1977, J.B. Platt, pers. comm. and pers. obser.). In some situations, Gyrfalcons vigorously attacked fixed-wing aircraft (D. Roseneau, pers. comm.). As noted above, Gyrfalcons have attacked a helicopter climbing toward them, and D. Mossop (pers. comm.), while surveying nests during inclement weather, had a number of Gyrfalcons attack a mostly white helicopter. The normal response of the study peregrine to the helicopter is demonstrated by the following account. On 8 June at 1050 H the male relieved the female at her brooding duties, and she flew to a nearby gully to perch. At 1130 H she took flight and began to soar as though she might be going to hunt. She was in a thermal and slowly started to rise, eventually going from 156 m to about 190 m

as she drifted south along the cliff line. We remained about 24 m from her. We maintained the front of the helicopter facing the falcon in an effort to keep it in sight forcing us to continually turn in a rather tight circle as though soaring. At 1135 she was immediately above the area occupied by a lone non-breeding female peregrine. The lone female promptly began to soar and soon reached the same altitude as the helicopter. A few stoops were made by each falcon at the other falcon. Both soared to within about 15 m of the helicopter and neither seemed to be concerned with it until at about that distance. A brief dodging movement was then made by each falcon away from the helicopter and then soaring was resumed. An adult male peregrine suddenly appeared with the other two soaring falcons, and he too began to soar. For about 2 min there were three peregrines and one helicopter all "soaring" within a 60 m area. At 1145 H the male started in a direct flight toward some presumably distant downriver locality (the next eyrie site was about 8.6 km downriver) and both females returned to their respective cliffs.

In a similar manner three of the Rough-legged Hawks nesting near the peregrine eyrie (see Fig. 1) attempted to "soar" with the helicopter. In that instance we had lost sight of the hunting male peregrine to view within a couple of minutes of leaving the eyrie and we were slowly turning the helicopter in tight circles scanning the horizon for him. Suddenly we noted two, and a few minutes later a third Rough-legged Hawk level with the helicopter (ca. 300 m altitude), all trying to soar. There was no rising thermal in spite of the "soaring" helicopter and the hawks slowly sank only to flap again to gain altitude opposite the helicopter. They were all within 30 m of the helicopter. We do not know how long they would have maintained this behavior, as we left to return to the falcon eyrie to await the arrival of the male. We have not followed in helicopter Prairie Falcons, Golden Eagles, Bald Eagles (*Haliaeetus leucocephalus*), or Osprey (*Pandion haliaetus*). Individuals of the latter three species have attacked helicopters and Golden Eagles and Ospreys have hit the aircraft and killed themselves (R.W.N., unpubl.).

Several times while the male peregrine was in a hunting soar he drifted to within about 18 m of the helicopter before he appeared to notice it. He usually made a quick turn and flew some 3–5 m further from the helicopter where he resumed hunting, looking at the ground again.



Figure 3. A female Gyrfalcon, being "shadowed" by a helicopter, calmly soared toward and then past within 12–15 m in front of the helicopter. The 2 m antenna on the helicopter's nose shows because the helicopter's slow forward motion was being stopped.

On 11 July the helicopter hovered about 14 m away from the cliff while the female completed an entire sequence of feeding young and then settled to brood without showing apparent distress from the presence of the helicopter. (See White and Sherrod 1973, for a photo from this feeding sequence and further discussion.)

Value of Helicopter Following. Most early studies on home ranges of raptors employed the technique of mapping locations where individual birds were seen on several days and then drawing minimum polygons that encompass all sightings (e.g., Craighead and Craighead 1956). Many later studies used radio telemetry (e.g., Cochran et al. 1965, Forbes and Warner 1974, Enderson and Kirven 1983). For long-distance travelers, such as the falcons we studied, the latter method would have been preferable but has serious logistical constraints. Data using either technique may not, however, correlate directly

with data collected by the method we used and thus comparisons may be difficult.

Data gathered from our studies were unlike two other studies of radio-telemetered nesting peregrines in several aspects. Mearns (1985) in Scotland determined the hunting ranges of two females near the end of the breeding season. An analysis of foods taken also gave some indication of the differential use of the habitat they hunted. Enderson and Kirven (1983) in California studied a male and female and while obtaining good data within 2 km of the eyrie they were uncertain about the extent of use of the main hunting areas. In such radio-telemetry studies the subject bird is out of sight of the investigator on most of the hunting flight and, apart from its approximate location on a map, only the most rudimentary behavioral information were obtained from the radio signal. (Using satellite tracking will of course eliminate the above problems.) While data from our per-

eprise study were obtained over a much shorter time than the above two, a very good indication of the differential use and extent of the hunting range was obtained. The falcon's behavior was continuously observed during hunting flights from start through prey capture and return, and the prey species, locations, and habitats hunted were recorded.

Because both Peregrine Falcons and Gyrfalcons tend to be tolerant of helicopters during certain parts of the breeding season and when they encounter the helicopter under certain conditions, following of these species can produce five kinds of information that are difficult or impossible to obtain through more conventional methods: 1) Hunting techniques, success, and duration, from the start of a hunt to the end can be recorded. 2) The habitats actually hunted and certain sites that are used for hunting more than other areas are identifiable. 3) Precise routes and elevations of hunting falcons can be determined. 4) Prey species actually attacked and different techniques used in various situations or with certain species can be observed. 5) Behaviors previously unrecognized in wide-ranging falcons may be detected.

Although the rental of a helicopter may be very expensive, in situations where the logistics are acceptable and the birds will tolerate the aircraft this technique is very competitive with other methods. In a relatively short time it can produce large amounts of detailed, unusual information about the travels, habitat use, and behavior of extremely mobile birds.

As a postscript, the young peregrines from the eyrie studied were depredated about 3 wk after the study ended (L.W. Sowl, pers. comm.) but either that pair or another used the same eyrie the following year.

ACKNOWLEDGMENTS

The peregrine study was funded by the Alyeska Pipeline Consortium (Service Company) under the supervision of U.S. Fish and Wildlife Service, Alaska area. LeRoy W. Sowl, USFWS, was helpful in securing funds. Hunter Ridenour, Evergreen Helicopters, piloted the aircraft. Personnel of the Franklin Bluff pipeline camp were helpful in providing logistics.

The Gyrfalcon study was funded by World Wildlife Fund (Canada) through Fred L. Bunnell. David Mossop and the Yukon Wildlife Branch provided major logistical and other support. Dean Cameron, Denise Harwood, Don Russell, and Jennifer A. Nelson assisted with aerial observations. Alora L. Nelson provided aerial and ground assistance in all phases of this and the parent study. Kerry Guenter, Trans North Turbo Air, flew the helicopter and played a major role in developing methods of "shadowing"

Gyrfalcons. We thank D.H. Ellis, D.E. Anderson, J.R. Parrish and an anonymous reviewer for helpful comments.

LITERATURE CITED

- ALERSTAM, T. 1987. Radar observations of the stoop of the Peregrine Falcon *Falco peregrinus* and the Goshawk *Accipiter gentilis*. *Ibis* 129:267-273.
- BENGSTON, S.A. 1971. Hunting methods and choice of prey of Gyrfalcons (*Falco rusticolus*) at Myvatn in northeast Iceland. *Ibis* 113:468-476.
- BIRD, D.M. AND Y. AUBRY. 1982. Reproductive and hunting behavior of peregrine falcons, *Falco peregrinus*, in southern Quebec. *Can. Field-Nat.* 96:167-171.
- CADE, T.J. 1982. The falcons of the world. Comstock, Cornell University Press, Ithaca, NY.
- CAMPBELL, R.W. 1975. Hunting tactics of a Peregrine Falcon on Black Turnstones. *Condor* 77:485.
- CLUNIE, F. 1976. A Fiji peregrine (*Falco peregrinus*) in an urban-marine environment. *Notornis* 23:8-28.
- COCHRAN, W.W. AND R.D. APPLEGATE. 1986. Speed of flapping flight of Merlins and Peregrine Falcons. *Condor* 88:397-398.
- , D.W. WARNER, J.R. TESTER AND V.B. KUECHLE. 1965. Automatic radio-tracking system for monitoring animal movements. *BioScience* 15:98-100.
- CRAIGHEAD, J.J. AND F.C. CRAIGHEAD, JR. 1956. Hawks, owls and wildlife. The Stackpole Co., Harrisburg, PA.
- DEKKER, D. 1987. Peregrine Falcon predation on ducks in Alberta and British Columbia. *J. Wildl. Manage.* 51:156-159.
- ENDERSON, J.H. AND M.N. KIRVEN. 1983. Flights of nesting Peregrine Falcons recorded by telemetry. *Raptor Res.* 17:33-37.
- FORBES, J.E. AND D.W. WARNER. 1974. Behavior of a radio-tagged Saw-whet Owl. *Auk* 91:783-795.
- FYFE, R.W. AND R.R. OLENDORFF. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Occas. Paper No. 23, Canadian Wildlife Service, Ottawa, Canada.
- HARRIS, J.T. AND D.M. CLEMENT. 1975. Greenland Peregrines at their eyries: a behavioral study of the Peregrine Falcon. *Meddel. om Gron.* 205(3):1-28.
- JENKINS, M.A. 1974. Behavior of the Gyrfalcon (*Falco rusticolus*) from hatching to fledgling: a time-lapse photographic study. M.S. thesis, Brigham Young University, Provo, UT.
- KISTCHINSKII, A.A. 1958. Zur Biologie des Jagdfalken auf der Kola-Halbinsel. *Ornitologija* 1:61-75.
- MEARNS, R. 1985. The hunting ranges of two female peregrines toward the end of a breeding season. *Raptor Res.* 19:20-26.
- MONNERET, R.J. 1973. Techniques de chasse du faucon pelerin dans une region de Moyenne Montagne. *Alauda* 41:403-412.

- . 1987. Le faucon pelerin. Editions du Point Veterinaire, Maisons-Alfort, France.
- PLATT, J.B. 1977. The breeding behavior of wild and captive Gyrfalcons in relation to their environment and human disturbance. Ph.D. thesis, Cornell University, Ithaca, New York.
- PORTER, R.D. AND C.M. WHITE. 1973. The Peregrine Falcon in Utah, emphasizing ecology and competition with the Prairie Falcon. *Brigham Young Univ. Sci. Bull. Biol. Series* 18(1):1-74.
- RUDEBECK, G. 1951. The choice of prey and modes of hunting of predatory birds with special reference to their selective effect. *Oikos* 3:200-231.
- SCHOENER, T.W. 1971. Theory of feeding strategies. *Ann. Review Ecol. and Syst.* 2:369-404.
- SHERROD, S.K. 1988. Behavioral differences in Peregrine Falcons. Pages 741-748 in T.J. Cade, J.H. Enderson, C.G. Thelander and C.M. White [Eds.], Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Inc., Boise, ID.
- TRELEAVEN, R.B. 1980. High and low intensity hunting in raptors. *Z. Tierpsychol.* 54:339-345.
- U.S. DEPT. INTERIOR. 1979. Snake River birds of prey special research report. Bureau Land Manage., Boise District, Boise, ID.
- WEIR, D. 1978. Wild Peregrines and grouse. *The Falconer* 7:98-102.
- WELCH, B. 1987. Hawks at my wingtip. North Country Press, Thorndike, ME.
- WHITE, C.M. 1963. Botulism and myiasis as mortality factors in falcons. *Condor* 65:442-443.
- AND R.B. WEEDEN. 1966. Hunting methods of Gyrfalcons and behavior of their prey (ptarmigan). *Condor* 68:517-519.
- AND T.J. CADE. 1971. Cliff-nesting raptors and ravens along the Colville River in Arctic Alaska. *Living Bird* 10:107-150.
- AND S.K. SHERROD. 1973. Advantages and disadvantages of the use of rotor-winged aircraft in raptor surveys. *Raptor Res.* 7:97-104.

Received 16 June 1989; accepted 26 January 1991

BIASES IN DIETS DETERMINED FROM PELLETS AND REMAINS: CORRECTION FACTORS FOR A MAMMAL AND BIRD-EATING RAPTOR

R.E. SIMMONS¹

Department of Zoology, University of the Witwatersrand, Johannesburg 2050, South Africa

D.M. AVERY AND G. AVERY

South African Museum, P.O. Box 61, Cape Town 8000, South Africa

ABSTRACT.—Numerous studies of predatory birds worldwide report dietary proportions based on analyses of large numbers of pellets or prey remains. Such analyses are often severely biased, hence strictly unquantifiable, because some prey remains are more conspicuous or persistent than others. We investigated this bias for the bird- and micromammal-eating African Marsh Harrier (*Circus ranivorus*), using an essentially independent measure of diet, observed prey deliveries to the nest. Comparisons of the frequency of occurrence showed that bird prey, particularly large wetland species, were over-represented almost threefold among remains. Micromammals were under-represented about 1.5-fold, while fish, frogs and eggs were marginally over-represented. Analyses using pellets were also biased but in the opposite direction to that of remains. We show that by combining pellets and prey remains (collected with equal effort), accurate estimates of overall diet can be achieved. This was verified using month by month comparisons of micromammals, in which proportions derived from pellets and remains never differed by more than 10% from those established from direct observations.

Parcialidad en los resultados para dietas determinadas por egagrópilas y residuos: factores de corrección para el caso de raptoras que se alimentan de mamíferos y aves

EXTRACTO.—Numerosos estudios sobre aves de presa, en todo el mundo, informan sobre proporciones de dietas basadas en el análisis de un gran número de egagrópilas, o en el de residuos de presas. Tales análisis con frecuencia resultan muy parcializados, por tanto no cuantificables, debido a que algunos de los residuos de presa son más conspicuos o persistentes que otros. Hemos investigado esta parcialidad, para aves de rapiña de la especie *Circus ranivorus*, las que se alimentan de aves y mamíferos muy pequeños. Hemos usado una medida de dieta esencialmente independiente, tal como la observación del acarreo de presas al nido. Comparaciones de la frecuencia de ocurrencias mostró que las presas constituidas por aves, particularmente especies grandes de zonas pantanosas, fueron sobre-representadas por los residuos casi en el triple. Mamíferos muy pequeños fueron sub-representados en aproximadamente 1.5; mientras que peces, ranas y huevos fueron marginalmente sobre-representados. Los análisis que usaron egagrópilas han sido también parcializados pero en sentido opuesto al de los residuos. Demostramos que combinando egagrópilas y residuos de presa, colectadas con igual cuidado, estimaciones precisas de la dieta general pueden ser logradas. Esto ha sido verificado usando, mes a mes, comparaciones de dietas constituidas por mamíferos muy pequeños, en las que las proporciones derivadas de egagrópilas y de residuos nunca difieren en más de 10% de las establecidas por observación directa.

[Traducción de Eudoxio Paredes-Ruiz]

It is probable that the majority of predator studies rely on prey remains in some form to determine the diet of their subject. This is particularly so for wide-ranging or elusive birds such as raptors both in Africa (e.g., Steyn 1982, Tarboton and Allan 1984, Boshoff et al. 1990), Europe (Newton and Marquiss

1982, Korpimäki 1985) and North America (review by Marti 1987). Indeed, for one group, owls, there is rarely any other way of assessing diet but from pellets (Jaksic and Marti 1981). While most studies acknowledge that prey remains at nests or feeding sites may not be representative of what is actually taken (Newton and Marquiss 1982), quantitative estimates of the biases inherent in such analyses are almost non-existent for wild birds. Several studies have, however, attempted this by feeding captive

¹ Present address: Ministry of Wildlife, Conservation and Tourism, Private Bag 13306, Windhoek, Namibia.

birds known diets and subsequently identified what occurs in the pellets (Yalden and Yalden 1985, Villegas 1990). Alternatively, wild birds can be observed or photographed with time-lapse cameras for long periods at the nest to determine what is delivered; these data may then be compared with simultaneously collected remains and pellets to determine the biases (e.g., Jarvis et al. 1980, Collopy 1983, Marti 1987). The ultimate goal is to determine what an individual is eating using a correction factor for each type of prey category assessed.

Our purpose here is to quantify the biases inherent in dietary analyses based on remains and pellets alone. We examine the diet of an avian predator, the African Marsh Harrier (*Circus ranivorus*), which consumes both birds and mammals ranging in size from tiny mice of 7 g to game birds up to 700 g. Specifically, we ask: are birds over-represented in remains and if so by how much do large birds predominate over small birds, are micromammals under-represented and do some mice predominate over others? We subsequently show that by combining data from pellets and remains, an accurate assessment of diet can be achieved.

We use the term "micromammals" in preference to the more usual "small mammals" to emphasize that only the extreme lower mass range of mammals on the African continent were captured by the harriers studied. Furthermore, we are solely concerned with the frequency of occurrence of prey in the diet, not the biomass. The biomass consumed by an individual is itself strongly biased when computed from average prey weights as advocated by some (e.g., Craighead and Craighead 1956, Steenhof 1983). This arises because mammalian prey of lower than average mass may be taken more frequently than predicted (e.g., MacWhirter 1985), bird prey in harrier diets are typically juveniles (e.g., Barnard et al. 1987, this study) and smaller raptors rarely consume all of the prey they capture (leaving major bones), again biasing upwards the biomass estimates computed. Ways of avoiding or alleviating these biases in the laboratory (Wijnandts 1984), field (Masman 1986, Simmons 1986a) or via statistical procedures (Marti 1987), have been discussed elsewhere.

STUDY AREA AND METHODS

In a 3-year study of African Marsh Harriers on the southern coast of South Africa (34°00'S 22°40'E), we collected and identified remains at nests and known feeding sites regularly from about one month before breeding until the young became independent (6–7 mo each year, Sim-

mons 1989). Collections varied, however, and generally yielded little at the start of breeding, increased for nests at which adults were incubating or brooding, and decreased as large or flying young found and consumed all prey left by the adults. Remains were sorted to identify individuals and subsequently removed. Extensive data on delivery patterns and prey types were concurrently collected at 19 nests over a three-year period (Simmons 1989). These observations, totalling 2200 h, began about 1 mo before breeding each year and were continued throughout breeding for 6 mo. Nest watches were also evenly spaced over the daylight period and results presented here are based on 701 observed deliveries to nests observed from hides placed 60–100 m away.

As a third measure of diet composition, we simultaneously collected pellets from the same pairs. To both concentrate pellet collections and protect them from ubiquitous mammalian carnivores, we provided perch posts for territorial males, and once birds began to regularly use them, wound chicken-wire baskets around posts to catch all regurgitated material. The baskets were high enough and afforded sufficient protection to thwart mongooses that visited such areas. We do not claim that all pellets cast were collected, but birds preferred our posts to their previously used ground roosts, thereby allowing a larger than usual sample. Harrier pellets, notoriously difficult to analyze because few bones, only teeth and skull parts remain undigested, were analyzed using extensive museum reference material. We thus had three partly independent measures of diet: remains, pellets and direct nest observations. Direct observations are judged the best indicator of diet (Marti 1987) because they represent a delivery by delivery account of what breeding harriers brought to their nests, and they also represent the largest most uniform sample. Naturally, this method is itself not completely representative of what each bird catches; not all of the largest or smallest items may be brought to nests because of foraging constraints (Simmons 1986b), and small or partly dismembered items were not always identifiable in the grasp of flying birds. We do not believe these are serious biases, however, because large items (>200 g), those most likely to be missed because they are not carried to the nest, comprised only 3% of all 707 identified prey, and very small items were frequently delivered.

RESULTS

Diet from Direct Observations. Of 701 prey items delivered to 19 harrier nests between 1984 and 1986, 374 could be identified. Of these, 74% were micromammals (rats, mice and shrews), and 23% passerines and waterbirds. The remainder comprised small frogs (2%) and fish (1%). Considering only the micromammals ($N = 326$), 89 could be identified to species; 51% were *Rhabdomys pumilio*, and 43% *Otomys irroratus*. The remaining 6% were shrews (Table 1). Micromammals, therefore, predominated in the diet of these marsh harriers.

Bird Prey Biases in Remains and Pellets. Of 82 remains collected at harrier nests or feeding areas,

Table 1. A comparison of the diet of African Marsh Harriers determined from direct observations, pellets and prey remains.

PREY TYPE	DIRECT OBSER- VATIONS (374) ^a	PELLETS (251) ^b	REMAINS (82)
Micromammals	74%	83%	48%
<i>Rhabdomys</i>	51%	38%	47%
<i>Otomys</i>	43%	44%	39%
Shrews	6%	8%	11%
Birds	23%	14%	40%
Frogs	2%	0%	4%
Fish	1%	2%	5%
Eggs	0%	1%	4%

^a Number of items within each category.

^b Number of individuals identified from 156 pellets.

40% were birds. Observed deliveries and pellets both showed that considerably fewer birds occurred in the diet, than found in remains (Table 1). Thus, remains at harrier nests or plucking areas over-estimated bird prey 1.7-fold according to direct observations (the most accurate method) and 2.9-fold according to pellets.

In pellets, however, the frequency of individual birds was under-estimated according to direct observations. Only 14% of all prey identified in pellets were birds, whereas direct observations showed that birds comprised 23% of the diet, a 1.6-fold difference. Thus the two methods either over-estimated (remains) or under-estimated (pellets) the proportion of birds in the diet. Pellets were marginally more accurate.

Biases Among Bird Prey. Wetland birds which were commonly seen in the area but never found or

Table 3. A comparison of the seasonal proportions of micromammals derived from pellets and remains, relative to those from direct observations (N = sample size).

MONTH	PELLETS AND REMAINS (N)	DIRECT OBSERVATIONS (N)
July	85% (26)	75% (4)
August	88% (65)	80% (71)
September	77% (70)	84% (110)
October	70% (44)	66% (105)
November	60% (53)	67% (67)
December–January	51% (41)	53% (19)

identified in pellets, included coots (*Fulica* sp.), various rallidae and flufftails (*Sarothrura* sp.). Such prey were, however, present in prey remains, and comprised 30% of the 40% total birds (Table 2). Birds that could be identified in pellets were typically smaller species (doves, warblers and weavers). Hence, large avian species were more likely to be found in remains and smaller species in pellets. We could not quantify the bias because of the large number of unidentified avian prey in pellets.

According to remains, avian prey became prominent from October (67%) and predominated thereafter (Table 2). Since harriers partially switch to young avian prey as mouse abundance and vulnerability declines (Simmons 1989), this was not unexpected. However, according to direct observations, birds never exceeded small mammals in the diet of these harriers. Once again, therefore, birds were over-estimated in remains.

Micromammal Prey Biases in Remains and Pellets. Of the 82 prey remains only 48% were micromammals—mainly *Rhabdomys pumilio* (46%)

Table 2. Summary of monthly differences in Harrier prey composition assessed from remains found at nests and plucking sites, 1984–1986.

	MICRO-MAMMALS	BIRDS	FROGS/FISH	EGGS	PROPORTION OF MAMMALS : BIRDS
July–August	16	2	2	0	79%:11%
September	12	6	2	2	57%:26%
October	3	10 [2] ^a	1	1	20%:67%
November	7	8 [4]	1	0	44%:50%
December–January	0	7 [1]	1	0	0%:88%
Totals	39	33 [7]	7	3	48%:40%

^a No. of juveniles in the total.

and *Otomys irroratus* (38%). Since micromammals comprised 73% of the diet from direct observations (Table 1), remains under-estimated this prey type 1.5-fold. However, for the two main species of micromammals, *Rhabdomys* and *Otomys*, the relative difference in their proportions (8%) was identical from both methods.

Pellets appeared to be the least accurate method of assessing which micromammals occurred most often in the diet, since our analyses suggested that more *Otomys* than *Rhabdomys* were eaten by harriers. By providing certain harriers with supplementary food (Simmons 1989), we could determine one reason why the large (50–200 g) *Otomys* were more likely to be found in pellets than the 30–80 g *Rhabdomys*; *Rhabdomys* were typically completely eaten except for a small section of the skull, including the jaw, which was often discarded. This was not so for *Otomys*. Hence the skeletal elements that provided the most reliable means of identifying this species would not always appear in the pellet. Under-representation of *Rhabdomys* in pellets was thus explicable.

Greater Musk Shrews (*Crocidura flavescens*), strongly scented 30 g insectivores, were observed being caught but discarded by African Marsh Harriers, presumably because of their strong musk and taste (cf. Smithers 1983). For example, in one case a complete specimen lay untouched at an active feeding site for 4 days. According to remains they should, therefore, be over-represented in the diet. This was so (Table 1), but samples are very small.

Other Prey Types. In general, other prey taken by harriers were more likely to be found in remains than either pellets or direct observation. Hence frogs and eggs were apparent in remains but were rarely recorded in pellets. The value of studying remains, therefore, lies in exposing the more unusual items rarely recorded by other methods.

Correcting Biases: Pellets and Remains Combined. When diet composition from prey remains and pellets were combined ($N = 333$), the proportion of micromammals in the diet (74%) was exactly that recorded from direct observations. Similarly, proportions of bird prey from pellets and remains (20%) were nearly identical to that found from direct observation (23%). Hence it seems that for harriers, remains and pellets can be combined to increase the accuracy of prey analyses. Similar conclusions were reached by Collopy (1983) studying Golden Eagles (*Aquila chrysaetos*).

As an additional check on the accuracy of this

possible correction factor we undertook a seasonal assessment, combining remains and pellets by month. Again, the correspondence between proportions of micromammals derived from remains and pellets were almost identical to that found by direct observation (Table 3). In any one month, the proportion of dietary micromammals found by pellets and remains, did not differ by more than 10% from that found by direct observations. The differences ranged from 2–10% (for the lowest sample size) and averaged 6.3%—a difference small enough to be explained by chance.

DISCUSSION

This study quantifies what many avian researchers have often suspected—that birds are seriously over-represented in the prey remains of mammal/bird-eating raptors. This is the first study, however, which attempts to both quantify and subsequently rectify such biases for a free-ranging raptor taking micromammals. That bird prey can be over-estimated almost threefold was unexpected, and shows the value in expending considerable time in determining diet from direct observation. Since avian researchers seldom have the time or perhaps the inclination to sit for hundreds of hours watching their quarry, we have provided a much simpler method of determining dietary intake. By combining pellets and prey remains we show that for any one month, proportions of micromammals differ by an average of 6% (and no more than 10%) from that actually observed. This considerable time-saving finding may also allow much greater accuracy for diet determination of raptors that are known (or suspected) to switch prey at certain seasons. That the method of combining pellets and remains gives accurate estimates for harriers (this study) and eagles (Collopy 1983), suggests that it may have a more universal application for mammal/bird-eating raptors than presently appreciated.

For these methods to be applicable in other studies it is necessary to determine the number of pellets and prey remains required, and in what proportions, for an accurate assessment of diet. In this study, we collected remains and pellets with equal effort on an approximately monthly basis. That pellets outnumbered remains (about twofold) was a natural phenomenon attributable to the harriers and not to any differential collecting effort. We also took care to increase our efficiency in pellet collecting, by providing perch posts within the territories of each har-

rier, thereby minimizing the numerous possible areas in which birds might cast pellets. As previously stated, these collections were also protected against ubiquitous mammalian predators.

In conclusion, it seems that the value of studying diet from direct observations lies in the consistency and accuracy of such a method. On the other hand, studying pellets allows a more accurate assessment of species composition, particularly small micro-mammals seldom recorded by direct observation. Lastly, the value of studying remains, while biasing the more common remains in favor of birds, allows us to determine more unusual prey such as eggs and fish. Each method, therefore, has its advantages. The most important point, however, is that it is possible, at least for harriers, to circumvent biases inherent in collecting just remains or pellets by combining them. Dietary proportions within about 10% of the "true" diet are then possible.

ACKNOWLEDGMENTS

Thanks are due to staff of the Cape Department of Nature and Environmental Conservation at Rondevlei for logistical support to R.E.S. throughout, and the National Parks Board for accommodation in 1984. Phoebe Barnard made valuable comments on a draft of this paper and Marc Bechard, Paul Steblein and Guy Cowlishaw aided presentation. Funding for D.M.A. was provided by the Foundation for Research Development (FRD) and the South African Museum and R.E.S. was funded from Wits University and the FRD.

LITERATURE CITED

- BARNARD, P.E., R.B. MACWHIRTER, R.E. SIMMONS, G.L. HANSEN and P.C. SMITH. 1987. Timing of breeding and the seasonal importance of passerine prey to breeding Northern Harriers (*Circus cyaneus*). *Can. J. Zool.* 65:1942-1950.
- BOSHOFF, A.F., N.G. PALMER AND G. AVERY. 1990. Regional differences in the diet of Martial Eagles in the Cape Province, South Africa. *S. Afr. J. Wildl. Res.* 20: 57-68.
- COLLOPY, M.W. 1983. A comparison of direct observations and collections of prey remains in determining the diet of Golden Eagles. *J. Wildl. Manage.* 47:360-368.
- CRAIGHEAD, J.J. AND F.C. CRAIGHEAD. 1956. Hawks, owls and wildlife. Stackpole Co., Harrisburg, PA.
- JAKSIĆ, F.M. AND C.D. MARTI. 1981. Trophic ecology of *Athene* owls in mediterranean-type ecosystems: a comparative analysis. *Can. J. Zool.* 59:2331-2340.
- JARVIS, M.J.F., M.H. CURRIE AND N.G. PALMER. 1980. Food of Crowned Eagles in the Cape Province. *Ostrich* 51:215-218.
- KORPIMÄKI, E. 1985. Prey choice strategies of the Kestrel *Falco tinnunculus* in relation to available small mammals and other Finnish birds of prey. *Annales of Zoologica Fennici* 22:91-104.
- MACWHIRTER, R.B. 1985. Prey selection and provisioning strategies of breeding Northern Harriers (*Circus cyaneus*). B.Sc. thesis. Mt. Allison University, NB, Canada.
- MARTI, C.D. 1987. Raptor food habits studies. Pages 67-80 in B.A. Giron Pendleton, B.A. Milsap, K.W. Cline and D.M. Bird [EDS.], Raptor management techniques manual. National Wildlife Federation, Washington, D.C.
- MASMAN, D. 1986. The annual cycle of the Kestrel *Falco tinnunculus*, a study in behavioral energetics. Ph.D. thesis, University of Groningen, The Netherlands.
- NEWTON, I. AND M. MARQUISS. 1982. Food, predation and breeding season in the Sparrowhawk (*Accipiter nisus*). *J. Zool. Lond.* 197:221-240.
- SIMMONS, R. 1986a. Ecological segregation of the Red-breasted Sparrowhawk (*Accipiter rufiventris*) and six co-existing accipitrine raptors in southern Africa. *Ardea* 74:137-149.
- 1986b. Food provisioning, nestling growth and experimental manipulation of brood size in the African Redbreasted Sparrowhawk (*Accipiter rufiventris*). *Ornis Scandinavica* 17:31-40.
- 1989. Adaptation and constraint in the breeding of subtropical harriers and eagles. Ph.D. thesis. University of the Witwatersrand, Johannesburg, South Africa.
- SMITHERS, R.H.N. 1983. The mammals of the southern African subregion. Pretoria University Press, Pretoria, South Africa.
- STEENHOF, K. 1983. Prey weights for computing percent biomass in raptor diets. *Raptor Research* 17:15-27.
- STEYN, P. 1982. Birds of prey of southern Africa. Croom Helm, Beckenham, U.K.
- TARBOTON, W. AND D. ALLAN. 1984. The status and conservation of birds of prey in the Transvaal. Transvaal Mus. Monogr. No. 3, Pretoria, South Africa.
- VILLAGE, A. 1990. The Kestrel. T&A.D. Poyser, Berkhamsted, U.K.
- WIJNANDTS, H. 1984. Ecological energetics of the Long-eared Owl (*Asio otus*). *Ardea* 72:1-92.
- YALDEN, D.W. AND P.E. YALDEN. 1985. An experimental investigation of examining Kestrel diet by pellet analysis. *Bird Study* 32:50-55.

Received 26 October 1990; accepted 9 February 1991

NEW GOLDEN EAGLE RECORDS FROM BAJA CALIFORNIA

RICARDO RODRÍGUEZ-ESTRELLA, JORGE LLINAS-GUTIÉRREZ AND
JORGE CANCINO

Centro de Investigaciones Biológicas, Apdo. Postal 128, La Paz, 23000, B.C.S., Mexico

ABSTRACT.—The Golden Eagle (*Aquila chrysaetos*) has been little studied in Mexico so that this species' population status in the southern extreme of its range is unknown. We present new records of the species for the mid and southern portion of Baja California. We describe the recovery of an eagle banded in Oregon and found dead in the Vizcaíno Desert, approximately 2000 km south of the banding location. Based on sightings and recoveries of dead eagles, we suspect that a resident breeding population exists in the region and that this population is augmented by migrants in winter.

Nuevos registros de Águila Real en Baja California

EXTRACTO.—El Águila Real (*Aquila chrysaetos*) ha sido muy poco estudiada en México, y prácticamente se desconoce la situación de sus poblaciones en el extremo más al sur de su distribución en América. Nosotros presentamos nuevos registros de la especie en la porción media y sur de la península de Baja California, México, así como el registro de un águila anillada en Oregón y que fue encontrada muerta en la zona del Desierto de Vizcaíno, aproximadamente a 2000 km de su lugar de origen. Finalmente se discute sobre el estatus del Águila Real en Baja California en relación a los individuos residentes e invernantes.

The Golden Eagle (*Aquila chrysaetos*) in North America is widely distributed, ranging from northern Canada and Alaska to north-central Mexico (Bent 1937, Brown and Amadon 1968); however, there is little information on the distribution and status of this eagle in Mexico (Le Franc and Clark 1983). Nothing appears to be published about breeding and migrant Golden Eagles in Baja California, particularly south of Sierra San Pedro Martir (Grinnell 1928). There are no museum specimens in Mexico or the United States from Baja California (P. Unitt, and P. Escalante, pers. comm.). We report on observations of Golden Eagles in the Peninsula of Baja California, and contribute new information on the distribution of these eagles at the southern end of their range.

Our observations consisted mainly of individuals from the mountains of the Vizcaíno Biosphere Reserve, although some individuals also were recorded farther south, on the tip of the Peninsula. We particularly surveyed the higher (San Francisco and La Higuera) and the lower (San Jose de Castro and Santa Clara) sierras, including the isolated mountains of El Pinacate and Cerro Prieto (Fig. 1). Elevations in the surveyed area range from 550–600 m in the lower mountains to 1400–1600 m in the higher mountains. Lower mountains are character-

ized by low precipitation (up to 100 mm annually) with a winter rainy season and a mean annual temperature of 22°C. High mountains receive 200–300 mm of annual precipitation with a summer and winter rainy season and have a mean annual temperature of 20°C (García and Mociño 1968). Vegetation of the area is desertic thicket, comprised mainly of mesquite (*Prosopis* spp.), Adam's Tree (*Fouquieria diguetii*), Palo Verde (*Cercidium microphyllum*), Cardons (*Pachycereus pringlei*) and several other cactus species (León de la Luz et al. in press). Potential prey for eagles are Black-tailed Jackrabbits (*Lepus californicus*), the endemic ground squirrel (*Spermophilus atricapillus*), California Quail (*Callipepla californica*) and Pronghorn Antelope (*Antilocapra americana peninsularis*). All of these species are locally common, except the pronghorn, which is endangered in the Vizcaíno desert (Wilcox 1988).

During April, July and October 1984, November 1987, February–March 1988 and October 1989, 13 Golden Eagles (10 adults, 1 subadult, and 2 immatures; see Clark and Wheeler 1987 for a description of age classes) were observed at different sites (Table 1). All were flying over mountains and valleys surrounded by hills. We did not observe evidence of reproductive activity, but in 1988, two probable Golden Eagle nests, one on the Sierra San Francisco

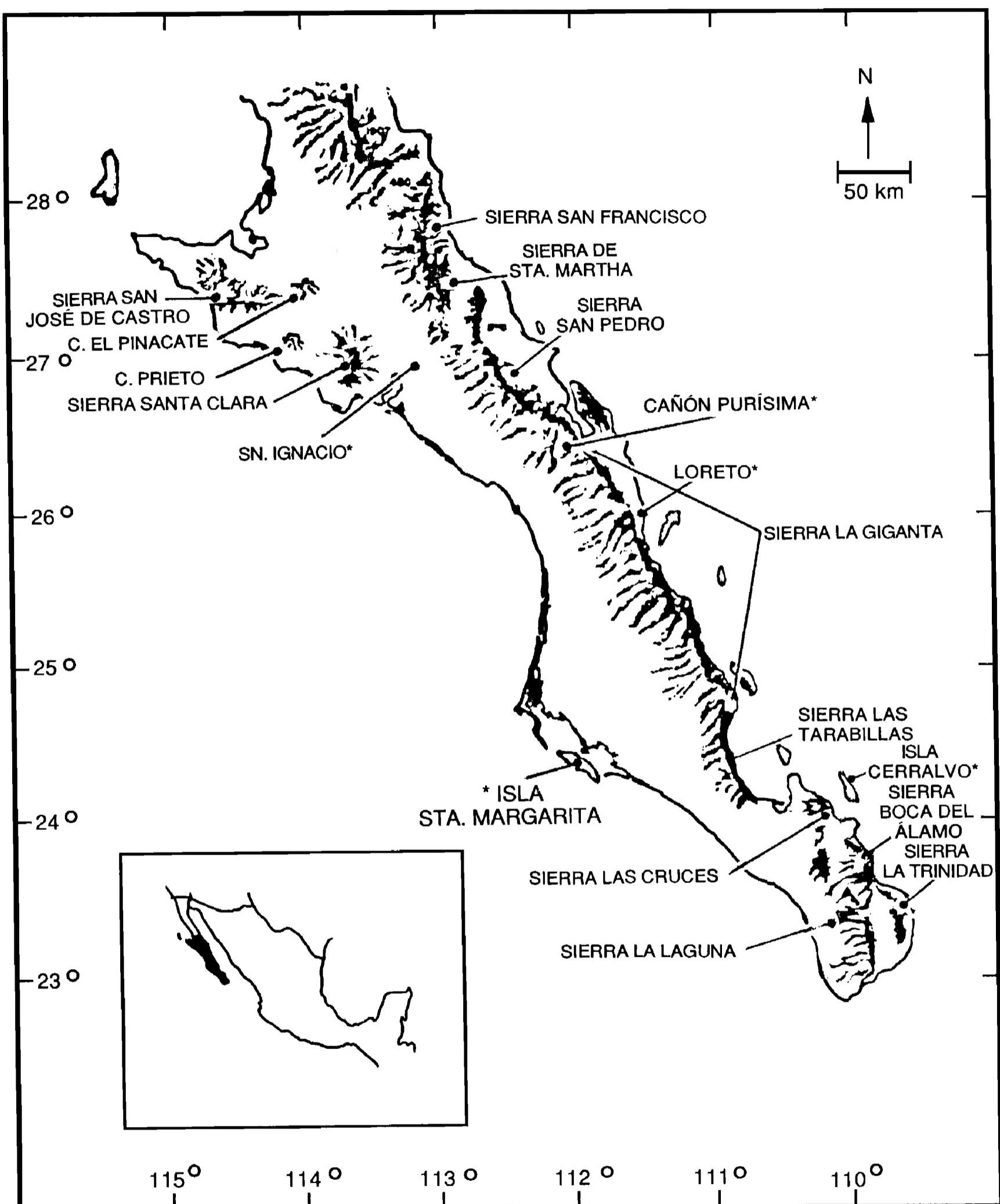


Figure 1. Golden Eagle records in Baja California Sur. Points show the locations where Golden Eagles were observed. Asterisks (*) indicate records from the literature.

Table 1. Golden Eagle records in Baja California. Records for this study were collected since 1984 in the southern end of the range of the Golden Eagle.

SITE	DATE	NUMBER OF INDIVIDUALS	SOURCE
North of Vizcaíno Desert			
Nachoguero (32°29')	5 October 1946	1	Hill and Wiggins 1948
Ensenada (31°43')	9 April 1967	1, ^a 1 ^a	Short 1967
Laguna Hanson (31°39')	21 October 1926	1 ^b	Grinnell 1928
	7, 8 October 1946	1, 2	Hill and Wiggins 1948
Santo Tomás (31°31')	16 October 1946	Several	Hill and Wiggins 1948
San Telmo (30°49')	— 1893	2 ^c	Anthony 1893 (cited in Grinnell 1928)
	21 October 1946	3	Hill and Wiggins 1948
San José (30°48')	October 1946	Nest ^d	Hill and Wiggins 1948
	20 October 1946	1	Hill and Wiggins 1948
San Quintín (30°31')	25 February 1925	1	Huey 1926
La Grulla (30°04')	15 June 1923	1	Huey 1926
San Fernando (29°59')	— 1895	1	Anthony 1893 (cited in Grinnell 1928)
El Mármol (29°48')	26 October 1946	1	Hill and Wiggins 1948
Isla San Lorenzo (28°31')	17 April 1977	1	Wilbur 1987
Vizcaíno Desert			
Cerro El Pinacate (27°32')	7, 9, 10–12 July 1984	1, 1, 1, 2, 2	This study
Sierra San Francisco (27°31')	11, 12 March 1988	1, 1	This study
	27 October 1989	2 ^a	This study
Sierra Santa Martha (27°25')	19 March 1988	1	This study
Sierra de la Cabra (27°24')	17 November 1987	1	This study
Sierra de Santa Clara (27°08')	14 October 1984	2	This study
San Ignacio (27°02')	17 January 1985	1	Wilbur 1987
San Hipólito (26°59')	13, 14, 17 April; 15 Oct. 1984	1, 2, 2; 2	This study
South of Vizcaíno Desert			
Cañón Purísima (26°20')	17 November 1946	1	Hill and Wiggins 1948
Loreto (25°53')	15 January 1985	1	Wilbur 1987
Isla Santa Margarita (24°24')	25 April 1984	1	Amador 1985
Isla Cerralvo (24°12')	26 October 1961	1	Banks 1963
Los Planes (24°05')	June 1988	1	This study (see text)
La Rivera (23°31')	November 1989	1	This study (see text)
Sierra de la Laguna (23°19')	25 January 1990	1, ^a 1	This study

^a Immature.

^b Skeleton in the Museum of Vertebrate Zoology, University of California, Berkeley.

^c Eagles nesting.

^d A nest in good repair in a *Pinus ponderosa*.

and one on the Sierra de la Higuera, were found on cliffs with an ENE exposure. They were both unoccupied at the time.

Some of the eagles observed in our study area may be from U.S.A. While interviewing ranchers, we found a banded foot of a Golden Eagle that had been killed by a shepherd in November 1986 at Sierra San Francisco (2 km east from Rancho Santa

Ana at 950 m elevation). This eagle was 10 years old when killed, was of unknown sex, and it was near fledging when banded in Oregon. Conservatively, this bird moved a minimum of 2000 km to arrive in the Sierra San Francisco. According to the shepherd, the eagle was accompanied by a second Golden Eagle.

Some Golden Eagles have been recorded sporad-

ically farther south along the Baja peninsula (Hill and Wiggins 1948, Banks 1963, Amador 1985, Wilbur 1987). Our data suggest that Golden Eagles occur in the southern portion of the Baja peninsula more commonly than previously believed. One injured adult eagle was trapped by a rancher on June 1988 near Los Planes village (site: El Médano Alto 24°01'30"N 109°55'15"W), and a sub-adult eagle was trapped alive by a rancher on November 1989, near La Rivera village (23°33'36"N 109°30'40"W) (Fig. 1) when the individual tried to chase a duck and had descended to the ground. On January 1990, we observed one immature (2–3 years old) and one adult in the pine-oak forest of Sierra de la Laguna (1800 m elevation; Fig. 1).

The status and distribution of Golden Eagles in Baja California has not been clearly determined. For example, there could be two Golden Eagle populations in the Vizcaíno Biosphere Reserve, one local and nonmigratory, and another migratory. Non-migratory residents might breed in the area, but currently there are no published records of this eagle nesting south of latitude 30°N in Baja California (Grinnell 1928, Short 1967, Wilbur 1987). However, based on our discovery of two probable Golden Eagle nests, the presence of two immatures in Sierra San Francisco, and the presence of one immature in Sierra de la Laguna we suggest it may be occurring. Alternatively, the presence of one migrant eagle from the U.S.A. in the Reserve area, as well as the increase in Golden Eagle abundance during the winter (according to the shepherd's information and the literature; Table 1), suggests this area may well be an important wintering area for the Golden Eagles migrating to Baja California.

Clearly, more information is needed to document the relationship between Golden Eagle populations of the U.S.A. and Mexico, particularly with respect to dispersal and migratory movements. We also need to determine more accurately the breeding range of this species in the peninsula of Baja California.

ACKNOWLEDGMENTS

We thank F. Hiraldo, M. Delibes, J. Bustamante, B. Sanabria, J.L. León de la Luz, and R. Cadena for their field assistance. P. Unitt identified the Sierra de la Laguna immature record. M. Collopy, M.N. Kochert, M.R. Fuller, S.R. Wilbur, J.R. Murphy, and B.A. Millsap made

helpful comments that improved previous drafts. For help with the English revision of this manuscript we thank F. Fauchet and D. Auriolles. Financial support was provided by Secretaría de Desarrollo Urbano y Ecología, Centro de Investigaciones Biológicas de B.C.S. and Secretaría de Programación y Presupuesto.

LITERATURE CITED

- AMADOR, E.S. 1985. Avifauna de la Isla Santa Margarita, B.C.S., México. Memoria presentada para optar al título de Biólogo Marino. Universidad Autónoma de Baja California Sur. La Paz, B.C.S., México.
- BANKS, R.C. 1963. Birds of Cerralvo Island, Baja California. *Condor* 65:300–312.
- BENT, A.C. 1937. Life histories of North American birds of prey. (Part 1.) U.S. National Museum, Bull. 167.
- BROWN, L. AND D. AMADON. 1968. Eagles, hawks and falcons of the world. Country Life Books, London, U.K.
- CLARK, W.S. AND B.K. WHEELER. 1987. A field guide to hawks of North America. Houghton Mifflin Co., Boston, MA.
- GARCÍA, E. AND P. MOCIÓN. 1968. Los Climas de la Baja California. Memoria 1966–1967 del Comité Nacional Mexicano para el Decenio Hidrológico Internacional. Instituto de Geofísica, Universidad Nacional Autónoma de México, Mexico City, Mexico.
- GRINNELL, J. 1928. A distributional summation of the ornithology of Lower California. *Univ. Calif. Publ. Zool.* 32:1–300.
- HILL, H.M. AND L. WIGGINS. 1948. Ornithological notes from Lower California. *Condor* 50:155–161.
- HUEY, H. 1926. Birds of northwestern Baja California. *Auk* 43:352–353.
- LE FRANC, M.N. AND W.S. CLARK. 1983. Working bibliography of the Golden Eagle and the genus *Aquila*. National Wildlife Federation, Washington, D.C.
- LEÓN DE LA LUZ, J.L., J. CANCINO AND L. ARRIAGA. In Press. Asociaciones fisonómico-florísticas y flora. Pages 83–119 in L. Arriaga and A. Ortega [EDS.], La Reserva de la Biosfera "El Vizcaíno." Centro de Investigaciones Biológicas de Baja California Sur, La Paz, México.
- SHORT, L.L., JR. 1967. Notes on the avifauna of northwestern Baja California. *Trans. San Diego Soc. Nat. Hist.* 14:281–300.
- WILBUR, S.R. 1987. Birds of Baja California. University of California Press. Berkeley, CA.
- WILCOX, B. 1988. 1988 Red List of Threatened Animals. International Union for Conservation of Nature and Natural Resources. Cambridge, U.K.

Received 29 October 1990; accepted 9 March 1991

SURVIVAL AND MOVEMENTS OF RELEASED REHABILITATED BALD EAGLES

MARK MARTELL, PATRICK REDIG, JILL NIBE AND GAIL BUHL¹

The Raptor Center at the University of Minnesota, St. Paul, MN 55108

DANIEL FRENZEL

Department of Fisheries and Wildlife, University of Minnesota, St. Paul, MN 55108

ABSTRACT.—Nineteen Bald Eagles (*Haliaeetus leucocephalus*) which had been injured and successfully rehabilitated were released and radiotracked to determine survival, movements and breeding attempts. The birds were released during the winter months of 1987–1990 along the Mississippi River in Minnesota. Survival of 13 eagles (68.4%) for more than six weeks after release was documented as was mortality for three. One released female nested for three years following her release and produced one chick in each of two of those years. Rehabilitated Bald Eagles can be successfully released into appropriate habitat where they will survive and breed, contributing to the conservation of the species.

Sobrevivencia y movimientos de Águila Cabeciblanca rehabilitada y puesta en libertad

EXTRACTO.—Diecinueve Águilas Cabeciblancas (*Haliaeetus leucocephalus*) que habían sido lastimadas, después de ser rehabilitadas exitosamente, fueron puestas en libertad; su sobrevivencia, sus movimientos y sus intentos de reproducción, han sido luego determinados por medio de radiocontrol. Las aves fueron sueltas durante los meses de invierno de 1987–1990, a lo largo del río Mississippi en Minnesota. La sobrevivencia de 13 águilas (68.4%) por más de seis semanas, después de ser sueltas; así como la muerte de dos, han sido documentadas. Una águila hembra de este grupo anidó por tres años seguidos, inmediatos a ser puesta en libertad, y en los dos últimos de esos años produjo una cría por año. Águilas Cabeciblancas rehabilitadas y sueltas en hábitats apropiados, sobrevivirán y se reproducirán, contribuyendo así a la conservación de la especie.

[Traducción de Eudoxio Paredes-Ruiz]

Rehabilitation and release of injured wildlife has become a widespread activity over much of North America with over 2500 permitted wildlife rehabilitators in the United States alone (E. Thrune, pers. comm.). While exact figures are not available, it can be assumed that many permittees handle birds of prey. One of the underlying goals of raptor rehabilitation is for a released bird to survive and resume “normal” activities. Most importantly, it is assumed, these birds become part of the breeding population, thus contributing to the conservation of their species (Fraser and Moss 1985).

Unfortunately, little effort has been made to document survival, or breeding success of released rehabilitated raptors. This information is critical when assessing the value of rehabilitation to the conservation of populations (Fraser and Moss 1985). Duke

et al. (1981) documented nesting by two released rehabilitated Bald Eagles (*Haliaeetus leucocephalus*) one and two years, respectively, after release. They also reported on band returns and incidental sightings of other raptors released from the University of Minnesota. Servheen and English (1979), reported on the movements of color-marked, rehabilitated Bald Eagles in the Pacific Northwest. Radiotelemetry was used by Hamilton et al. (1988) to monitor the survival of eight Red-tailed Hawks (*Buteo jamaicensis*) and one Red-shouldered Hawk (*Buteo lineatus*) in Louisiana.

Our study monitored the survival, movements, and breeding attempts of rehabilitated Bald Eagles released during winter (Nov.–March) from The Raptor Center at the University of Minnesota (TRC). Since 1974, TRC has treated over 630 Bald Eagles for a variety of ailments including fractures, soft tissue injuries, poisoning, and disease. Over 50% of the eagles admitted to TRC have been released to the wild.

¹ Present address: Carpenter St. Croix Valley Nature Center, Hastings, MN 55033.

Table 1. Admission and release information for released rehabilitated bald eagles held at The Raptor Center at the University of Minnesota 1987-1990.

CASE NUM- BER	AGE	SEX	CAUSE OF IN- JURY	TYPE OF INJURY/ TREATMENT	DAYS IN CLINIC	RELEASE SITE	RELEASE DATE	DAYS TRACKED	MAX. DIST. TRAV- ELED (KM)
N-370	Ad	M	Tp	Toe	23	CNC	22/11/87	126	30
N-374	Ad	F	Tp	Halux/amputation	38	CNC	06/12/87	80	500
N-415	Sub	F	Tp	Toe/amputation	25	PEI	15/12/87	854	—
N-408	Ad	F	Tp	Toe/amputation	30	PEI	15/12/87	71	—
N-390	Sub	U	Tp	Halux/amputation	42	PEI	18/12/87	67	610
N-263	Juv	M	Cv	Starvation	122	CNC	20/12/87	2	—
N-369	Juv	U	Pr	Wing fracture (ulna)	90	PEI	25/01/88	52	16
O-002	Ad	M	Tp	Toe/amputation	40	PEI	12/02/88	6	16
M-209	Juv	U	Mt	Wing soft tissue inj.	522	PEI	12/02/88	66	—
O-103	Sub	F	Mt	Unable to fly	184	CNC	08/11/88	29	129.6
O-430	Sub	M	Pr	Wing fracture (ulna)	55	CNC	11/12/88	1	25.6
O-335	Sub	U	Mt	Starvation	498	CNC	06/11/89	172	40
P-353	Ad	F	Mt	Wing fracture (ulna)	132	CNC	08/11/89	63	10.4
P-271	Ad	F	Mt	Unable to fly	139	MI	01/12/89	—	—
O-414	Juv	U	Pr	Wing fracture (ulna)	420	CNC	05/12/89	143	53
P-439	Juv	F	Mt	Wing fracture (ulna)	51	CNC	11/12/89	102	12
P-412	Sub	F	Pr	Wing fracture (humerus)	85	CNC	05/01/90	111	21
P-452	Sub	M	Pr	Wing fracture (ulna)	79	CNC	17/01/90	48	19
P-506	Juv	U	Mt	Coracoid fracture	79	CNC	12/02/90	29	55

¹ Tp = leg hold trap injury, Pr = projectile injury, Mt = miscellaneous trauma, Cv = collision with vehicle.

METHODS

Nineteen Bald Eagles admitted to TRC with injuries including wing fractures, starvation, and toe and foot damage from leg-hold traps (Table 1) were selected for use in this study. Injuries were repaired and the birds determined ready for release using standard TRC rehabilitation techniques described elsewhere (Redig et al. 1983, Martell and Redig 1985, Chaplin et al. 1989, Chaplin 1989). Amount of time each bird spent in treatment at TRC varied widely, from 23 to 522 d ($\bar{X} = 139.7$, N = 19) and was related to the nature of the injury. Fourteen birds were sexed using morphometric measurements (Garcelon et al. 1985), and all birds were aged using eye and beak color and plumage characteristics (first year birds = juvenile, subadult, and adult) using the characteristics described by Stalmaster (1987).

Eagles were released between November and February, 1987-1990 (Table 1) at release sites chosen for their location within Bald Eagle wintering habitat (Millsap 1986, Dunstan 1987) and known local use by Bald Eagles (Lane et al. 1986, Anonymous 1987, Dunstan 1987). Twelve eagles were released at the Carpenter St. Croix Valley Nature Center (CNC) on the St. Croix River, two miles north of the confluence of the Mississippi and St. Croix Rivers. Six birds were released at Pigs Eye Island (PEI) located on the Mississippi River south of Holman Airfield

in St. Paul at river mile (rm) 834. One bird was sent back to its point of recovery near Saginaw, Michigan. Both the PEI and CNC locations are regular winter TRC Bald Eagle release sites.

All released eagles were marked with a standard U.S. Fish and Wildlife Service aluminum leg band. Nine birds were fitted with white, wrap-around patagial markers (Young and Kochert 1987) alpha-numerically coded with orange herculite sewn onto the dorsal and ventral sides. Use of patagial markers on adult birds was discontinued after the first year and on immature birds after the second year due to concerns about the effects of wing tags on avian reproduction rates (Kinkel 1989), and our own observations of patagial injuries due to marker use.

Ten birds were fitted with a tail-mounted radiotransmitter operating in the frequency range 164.010 and 164.250 KHz (Advanced Telemetry Systems, Bethel, Minnesota) with an expected battery life of 120 d. The radio was attached to a central rectrix by tightening a clamp around the base of the feather shaft and the 17.6 cm antenna was secured to the feather with surgical thread. Both the radio and the antenna were also secured with epoxy glue. The total package weighed 25 g.

Nine birds were fitted with backpack mounted transmitters (Communication Specialists, Orange, California) with an expected battery life of three years. The radio was attached with a teflon ribbon running over the bird's shoul-

ders and under its wings (Kenward 1987) with the antenna resting freely along the dorsal surface of the bird. The total package weighed 90 g.

Radio signals were located from the ground and from a fixed wing aircraft with a Model CE 12 portable receiver (Custom Electronics, Urbana, Illinois) with a three-element collapsible yagi antenna, and later two Cedar Creek Model 2000 programmable scanning receivers with four-element yagi antennas. Air tracking was done with a scanning receiver connected via a switch box to two, four-element yagi antennas affixed to the wing strut of a Cessna 152 or 172 aircraft (Gilmer et al. 1981).

Daily radio triangulations were attempted on each bird for the first 10 d after release and at least once a week for as long as the bird was north of the Minnesota-Iowa border. Weekly flights along the St. Croix and Mississippi Rivers south to the Minnesota-Iowa border were made from November through March to census wintering Bald Eagles and locate radio-tagged eagles. Four additional flights to locate birds were made between December 1987 and March 1988 in central and western Minnesota, and to St. Louis, Missouri and Omaha, Nebraska. Tracking was discontinued around 15 April each year. Relocations were plotted on 1:24 000 U.S. Geological Survey or U.S. Army Corp of Engineers Navigation maps. Comparisons between groups of birds were made using Student's *t*-test.

RESULTS

Nineteen eagles were released during this study: seven juveniles, five subadults, and seven adults. There were eight females, six males and five birds of undetermined sex (Table 1). Six birds (31.6%) had toe injury or loss, eight (42.1%) had wing fractures, three (15.8%) were unable to fly due to soft tissue damage or unknown causes, and two (10.5%) were starving at the time of their admittance.

A total of 356 radio-relocations were obtained from 18 eagles during the three-year study ($\bar{X} = 19.8$, range 1–63). No band recoveries were reported to us through the Bird Banding Lab. Patagial markers were useful in identifying individuals that were in groups of eagles but did not provide any additional sightings.

Fifteen eagles (78.9%) survived for at least 10 d after release and 13 eagles (68.4%) survived over 6 wk after release. The longest known survivor was a female (P-415, Table 1) for whom near continuous relocations were obtained for 835 d after release. If we had contact beyond 10 d after release, we were able to maintain contact for an average of 134.2 d ($N = 15$). The same female (P-415) nested for three years following her release on Pigs Eye Island. Fertile eggs were laid in 1988, but the nest was blown down in a windstorm about 10 d after incubation started. The pair successfully fledged one chick in both 1989 and 1990.

Mortality was recorded for three released eagles. A bird (O-103, Table 1) released on 8 November 1988, was caught in a leg-hold trap 29 d later, 129.6 km from the release site. The bird was readmitted to TRC, however, the extent and nature of the injuries necessitated euthanasia. Based on the length of the bird's survival and generally good physical condition, we considered this bird as "successfully released." The second mortality (P-271, Table 1) was recorded of a bird released at Saginaw, Michigan on 1 December 1989. The carcass of this bird was found in early January 1990 and we did not consider this bird successfully released. The third mortality occurred in December 1990 to a bird (P-506, Table 1) released in February 1990 at CNC. The bird was recovered near Blind River, Ontario approximately 800 km northwest of the release site. The cause of mortality in this successfully released bird was Pb poisoning (B. Hunter, pers. comm.).

Signals from four eagles (21%) were lost within 10 d of release. One bird (discussed above) was found dead; the fate of the other three is unknown. All three of these birds were wearing tail-mounted transmitters. We did not lose contact with any eagles fitted with backpack style transmitters.

All relocations occurred along the Mississippi or St. Croix Rivers and associated waterways. Of 15 birds tracked for more than two d, 12 stayed within 5 km of the release site for at least three d after release, and the other three were found within 10 km of their release site for at least five d following release.

The greatest distance eagles were radiotracked from their release sites ranged from 2–610 km ($\bar{X} = 107$ km, SD = 194 km, N = 14). Birds released during the first year of the study traveled farther ($\bar{X} = 168$ km) than the birds released during the third year of the study ($\bar{X} = 30$ km; $t = 1.37$, $P > 0.1$, df = 12). Lack of data prevents comparisons to year two of the study. There was no significant difference in travel distance between males ($\bar{X} = 22$ km, N = 4) and females ($\bar{X} = 99$ km, N = 6) or between adult ($\bar{X} = 112$ km, N = 5) and immature birds (subadults and juveniles) ($\bar{X} = 89.2$ km, N = 11).

DISCUSSION

We have shown that Bald Eagles can be treated for a variety of injuries, using proper veterinary and rehabilitation techniques, and survive after release in appropriate habitat. Furthermore, we have documented that rehabilitated Bald Eagles can repro-

duce, and will seemingly integrate back into the larger Bald Eagle population.

Injuries to eagles used in this study were representative of injuries seen in all eagles admitted to TRC. Most injuries were severe and in five cases required amputation of a digit. Four eagles including the breeding female and two birds (one adult, one subadult) who traveled the greatest distance survived more than 9 wk. This indicates that both immature and adult Bald Eagles can adapt successfully to the surgical loss of a digit reinforcing the importance of immediate, proper treatment of leg-hold trap injuries in Bald Eagles. Seven released eagles were treated for fractures, and were able to resume normal functions in the wild.

Our findings that eagles remained near release sites for the first few days after release are similar to what Hamilton et al. (1988) found with Red-tailed Hawks in Louisiana. Servheen and English (1979) also noted that the Bald Eagles they released remained in the local area for 3–4 d. They attributed this to poor muscle condition. Birds released in this study were exercised regularly (Chaplin 1989, Chaplin et al. 1989) and we considered their flight condition excellent.

The tendency of released raptors to remain in the release area is important for rehabilitators to consider when choosing release sites. Release locations should be capable of satisfying the immediate needs (particularly food and shelter) of the bird for at least 3–5 d after release. Choosing a release site where the bird may be in competition with others, is forced to fly a great distance, or is marginal habitat may disadvantage the newly released bird.

Movements by released individuals were always along river corridors and followed seasonal patterns expected of wintering Bald Eagles in the upper Midwest (Dunstan 1987), an indication the birds had adjusted to release. Longest distance traveled by one of our birds (610 km) was greater than the 364 km reported by Duke et al. (1981) or the 332 km reported by Servheen and English (1979). This most likely reflects both the length of the Mississippi River wintering grounds and the amount of relocation effort expended in this study. Eagles released in the first year of the study traveled farther than in the third year which we attribute to severe weather in the winter of 1987/88. Larger portions of the Mississippi River bordering Minnesota were frozen, reducing the amount of food available to eagles, forcing them to move farther south.

Survival, movements on the wintering grounds, and reproductive success of released rehabilitated Bald Eagles shows that the time and money spent on rehabilitation can result in returning healthy, reproductively fit individuals back into the population. Impacts on the conservation of the population will depend on number, age, and possibly sex of released birds. Further work is needed in looking at the success rate associated with particular injuries and diseases, especially lead poisonings and exposure to other toxic chemicals.

ACKNOWLEDGMENTS

Financial and logistic assistance for this project was provided by the Minnesota Department of Natural Resources, Nongame Program, the George A. Hormel Company, and the members of The Raptor Center at the University of Minnesota. Logistic assistance and equipment from Communication Specialists Inc., North Central Experiment Station, U.S. Forest Service, and the Carpenter Nature Center are gratefully acknowledged. Joan Galli and Dick Holtzlider of the Minnesota Department of Natural Resources are gratefully acknowledged for their air surveys and radiotracking. Bill Bowerman arranged for radiotracking of an eagle released in Michigan. Advice on trapping, marking and radio-tagging techniques was generously shared by Al Harmata and David Garcelon. Special thanks to the 28 volunteer field assistants who helped observe and track eagles for this project. The comments of Lori Mueller and two anonymous referees greatly improved the manuscript.

LITERATURE CITED

- ANONYMOUS. 1987. Biological assessment on Bald Eagles: St. Paul downtown airport. Unpublished report submitted to Metropolitan Airports Commission, St. Paul, MN.
- CHAPLIN, S.B. 1989. Guidelines for exercise in rehabilitated raptors. *Wildlife J.* 12:17–20.
- , L. MUELLER AND L. DEGERNES. 1989. Physiological assessment of rehabilitated raptors prior to release. *Wildlife J.* 12:7–8, 17–18.
- DUKE, G.E., P.T. REDIG AND W. JONES. 1981. Recoveries and resightings of released rehabilitated raptors. *J. Raptor Res.* 15:97–107.
- DUNSTAN, T.C. 1987. Preliminary management strategy and plans for Bald Eagles wintering on the upper Mississippi River. Unpublished reports submitted to Iowa Conservation Commission, Des Moines, IA.
- FRASER, J.D. AND M.B. MOSS. 1985. Comment: a need for agency policies on wildlife rehabilitation. *Wildl. Soc. Bull.* 13:202–204.
- GARCELON, D.K., M.S. MARTELL, P.T. REDIG AND L.C. BUOEN. 1985. Morphometric, karyotypic, and laparoscopic techniques for determining sex in bald eagles. *J. Wildl. Manage.* 49:595–599.
- GILMER, D.S., L.M. COWARDIN, R.L. DUVAL, L.M.

- MECHLIN, C.W. SHAIFFER AND V.B. KEUCHELE. 1981. Procedures for the use of aircraft in wildlife biotelemetry studies. U.S. Department of Interior, U.S. Fish and Wildlife Service, Res. Publ. 140, Washington, DC.
- HAMILTON, L.L., P.J. ZWANK AND G.H. OLSEN. 1988. Movements and survival of released rehabilitated hawks. *J. Raptor Res.* 22:22-26.
- KENWARD, R.E. 1987. Wildlife radiotagging: equipment, field techniques, and data analysis. Academic Press, London, U.K.
- KINKEL, L.K. 1989. Lasting effects of wing tags on ring-billed gulls. *Auk* 106:619-624.
- LANE, W.H., M.S. MARTELL AND P.T. REDIG. 1986. Winter activity of Bald Eagles at Pigs Eye Island #1 on the Mississippi River. Unpublished report submitted to Minnesota Department of Natural Resources, St. Paul, MN.
- MARTELL, M.S. AND P.T. REDIG. 1985. Quantitative evaluation of the physical condition of the raptor patient prior to release. Pages 131-134 in P. Beaver [ED.], *Wildlife rehabilitation*. Vol. 4. Exposition Press, Smithtown, NY.
- MILLSAP, B.A. 1986. Status of wintering Bald Eagles in the conterminous 48 states. *Wildl. Soc. Bull.* 14:443-440.
- REDIG, P.T., G.E. DUKE AND P. SWANSON. 1983. The rehabilitation and release of Bald and Golden eagles: a review of 245 cases. Pages 137-148 in D.M. Bird, N.R. Seymour and J.M. Gerrard [EDS.], *Biology and management of Bald Eagles and Osprey*. Harpell Press, Ste. Anne de Bellevue, PQ, Canada.
- SERVHEEN, C. AND W. ENGLISH. 1979. Movements of rehabilitated bald eagles and proposed seasonal movement patterns of bald eagles in the Pacific Northwest. *J. Raptor Res.* 13:79-88.
- STALMASTER, M.V. 1987. *The Bald Eagle*. Universe Books, New York.
- YOUNG, L.S. AND M.N. KOCHERT. 1987. Marking techniques. Pages 125-156 in B.A. Giron Pendleton, B.A. Millsap, K.W. Cline and D.M. Bird [EDS.], *Raptor management techniques manual*. National Wildlife Federation, Washington, DC.

Received 29 October 1990; accepted 9 March 1991

FORAGING HABITS, HUNTING AND BREEDING SUCCESS OF LANNER FALCONS (*Falco biarmicus*) IN ISRAEL

REUVEN YOSEF¹

*Mitrani Center for Desert Ecology, Blaustein Institute for Desert Research and Department of Biology,
Ben-Gurion University, Sede Boqer Campus, 84993 Israel*

ABSTRACT.—The distribution of Lanner Falcons (*Falco biarmicus*) is restricted to the Mediterranean region and Africa. During 1987–89, data were collected on foraging habits and reproductive success on two breeding pairs of Lanner Falcons at Sede Boqer, in the Negev Desert highlands, Israel. Three hundred and thirty two capture attempts of birds, mammals and insects by the Lanner Falcons were observed, of which 163 (49.1%) were successful. The falcons also pounced on 9 rodents from a perch, or walked on the ground and gathered invertebrates on 27 occasions. A male also hunted bats. Pairs hunted cooperatively during the courtship period prior to egg laying, and also when young accompanied one of the parents on hunting forays. During the fledging period, the male and the female again hunted cooperatively. The overall hatching success for both pairs during the five pair-years was 95.2% and total fledging success was 78.3%.

Hábitos en la alimentación, cacería y reproducción de halcones de la especie *Falco biarmicus*, en Israel

EXTRACTO.—La distribución de halcones de la especie *Falco biarmicus* está restringida a la región mediterránea y África. Durante 1987–89 se han recogido datos sobre los hábitos de caza y de reproducción de dos parejas de halcones (*F.b.*), en Sede Boqer, en las alturas del desierto Negev en Israel. Se observaron 332 intentos, hechos por estos halcones, para la captura de aves, de mamíferos y de insectos. De estos intentos 163 (49.1%) tuvieron éxito. Los halcones también embistieron desde una perchta sobre 9 roedores; o recolectaron invertebrados, en 27 ocasiones, caminando sobre el suelo. Un halcón macho también cazó murciélagos. La caza cooperativa en las parejas ocurrió durante el período del cortejo, antes de la puesta de los huevos, y también cuando las crías acompañaron a uno de los padres en sus salidas de cacería. Durante el período de los primeros vuelos de las crías, los padres nuevamente cazaron cooperativamente. El total de incubaciones con éxito para ambas parejas durante los 5 años/pareja fue de 92.5%; y el total de éxito en los primeros vuelos fue de 78.3%.

[Traducción de Eudoxio Paredes-Ruiz]

STUDY AREA AND METHODS

The study was done in the vicinity of Sede Boqer (30° 52'N 34° 47'E; 475 m above sea level) in the Negev Desert highlands, that are part of the Saharo-Arabian desert belt. This area is arid, with 250–300 biologically dry days per year (UNESCO 1977).

One pair of falcons nested to the west of Divshon Canyon, the second pair nested in the Akev Canyon. I visited nest ledges several times a month, at irregular intervals throughout the year and carried out weekly observations during the breeding season (February–June). During egg laying and incubation, I limited visits to 10 min or less, while I observed through a 20× telescope and/or 10 × 40 binoculars. The nest of the western pair was first discovered in April 1978 by personnel of the Sede Boqer Field Study Center. Although records were kept of the pair's nesting attempts, no data on clutch size, hatching success or fledging success were available prior to my

¹ Present address: Department of Zoology, Ohio State University, Columbus, OH 43210.

Table 1. Food habits of Lanner Falcons at Sede Boqer, Israel.

	PAIR		TOTAL ITEMS	PERCENT
	EASTERN	WESTERN		
Prey taken	72	91	163	100.0
Prey caught in the air			136	82.9
Prey caught from perch			3	1.6
Prey caught by walking			27	15.5
Birds				
<i>Alectoris chukar</i>	29	40	72	43.1
<i>Pterocles</i> sp.	10	11	21	12.6
<i>Columba livia</i>	9	5	15	9.0
<i>Ammoperdix heyi</i>	3	2	5	3.0
<i>Passer</i> sp.	1	3	4	2.4
<i>Streptopelia</i> sp.	—	2	2	1.2
<i>Galerida</i> sp.	1	—	1	0.6
Unidentified	7	4	11	6.6
Total	60	67	127	78.5
Mammals				
<i>Psammomys obesus</i>	2	—	2	1.2
<i>Lepus capensis</i>	1	—	1	0.6
Insectivorous bats	—	5	5	3.0
Unidentified	1	—	1	0.6
Total	4	5	9	5.4
Invertebrates				
Ants	7	6	13	7.7
Grasshoppers	—	5	5	3.0
Beetles	1	4	5	3.0
Unidentified	—	4	4	2.4
Total	8	19	27	16.1

study. The nest of the eastern pair was discovered in 1984 (Frumkin 1986). I collected data on nesting success from the western nest in 1987–89 and eastern nest in 1988–89.

RESULTS AND DISCUSSION

Food Habits and Hunting. All foraging observations were made on the flat loessal plain, Sede Zin, located to the north of the Zin riverbed, in the immediate vicinity of the nest sites (approximate 1 km radius). I observed 332 capture attempts by the Lanner Falcons of birds, mammals and insects. Of these 163 (49.1%) were successful. The western pair made 153 capture attempts and was successful in 91 (59.5%). The eastern pair made 179 attempts of birds, of which 72 (40.2%) were successful. In 82.9% of observations the prey was caught in flight. Most birds (63.2%) were taken from a stoop, often after the falcon had been circling high. At times (5.2% of

observations) a falcon dropped below the prey and grasped it from below and behind.

Sixty-nine of the bird prey items captured were chukars (*Alectoris chukar*; Table 1). Other identifiable birds were sandgrouse (*Pterocles* sp.), Rock Doves (*Columba livia*), Sand Partridges (*Ammoperdix heyi*), sparrows (*Passer* sp.), Ring-necked Doves (*Streptopelia* sp.), and larks (Alaudidae sp.).

The falcons also pounced on 9 rodents from a perch, or walked on the ground and gathered invertebrates on 27 occasions. This concurs with the descriptions of Lanner Falcons observed foraging in Africa (Brown et al. 1982). I saw a lanner capturing and carrying a Fat-tailed Sand Rat (*Psammomys obesus*) twice. The female of the eastern pair also was seen in flight with a hare (*Lepus capensis*) in its talons. Because of the proximity of the sighting to

Table 2. Hunting success of adult Lanner Falcons at Sede Boqer, Israel. Data are based on observations during 1987–89. Averages are represented ± 1 standard deviation. Data include various kinds of prey (birds, mammals and insects).

	WESTERN PAIR		EASTERN PAIR	
	MALE	FEMALE	MALE	FEMALE
ALONE				
Attempts	43	19	29	49
Kills	19	7	9	26
Percent successful	44.2	36.8	31.0	53.1
COURTSHIP COOPERATIVE HUNTING WITH MATE				
Attempts	11	11	11	11
Kills	5	6	7	7
Percent successful	45.5	54.5	63.6	63.6
BREEDING				
Attempts	34	3	37	4
Kills	14	1	16	2
Percent successful	41.2	33.3	43.2	50.0
COOPERATIVE HUNTING WITH YOUNG				
Attempt	19	13	19	19
Kills	8	8	11	13
Percent successful	42.1	61.5	57.9	68.4
Total attempts	107	46	179	83
Kills	46	22	95	48
Hunting success	$43.3 \pm 4\%$	$47.1 \pm 14\%$	$53.7 \pm 7\%$	$58.7 \pm 9\%$

the highway, it is possible that the hare was a scavenged road kill.

The western male also hunted bats. For three consecutive days, during March of 1989, I observed the male foraging at dusk over the community swimming pool. He circled overhead and dived towards bats that were skimming over the water. He chased the bats from behind and above, and caught 5 in 17 attempts (29%). One of the bats captured was a European Free-tailed Bat (*Tadarida teniotis*), the others were Kuhl's Pipistrel (*Pipistrellus kuhlii*). Two of the five bats were taken to the nesting cliff, the others were consumed in a nearby tree. On all occasions the wings were removed prior to ingestion. This concurs with similar observations by Tout (1986), Thomsett (1987) and van Jaarsveld (1988).

During late summer and autumn (mid-June to late November) all observations were of individual falcons hunting separately ($N = 47$) and feeding alone ($N = 22$; Table 2). They hunted cooperatively during the courtship period prior to egg laying, and also when young accompanied one of the parents on

hunting forays. Adult Lanner Falcons may use cooperative hunting to teach their young different hunting tactics, and to enhance hunting success (Hector 1986). Cooperative hunting has also been reported in Lanner Falcons from elsewhere in the species range (Cramp and Simmons 1980). In late December, males and females hunted cooperatively 11 times. The male mainly flushed and chased the prey (17 of 22 observations), usually in the direction of the female (14 of 22 observations). Upon detecting the female, the prey either turned back toward the male (7 observations) or kept flying into the flight path of the female (12 observations).

From late February to April, when the female was on eggs or with nestlings, the male supplied almost all the food to the female and young (50 to 53 observed visits to nest). The female left the nest area for short periods, during which the male remained in the vicinity. Only rarely was she seen to hunt. On three occasions the female was observed to catch Rock doves. This concurs with descriptions by Brown et al. (1982).

During the fledging period, when young were in

Table 3. Breeding success of two pairs of Lanner Falcons in Israel. The pairs were observed during the years 1987–89.

	WESTERN PAIR			EASTERN PAIR		
	EGGS		YOUNG FLEDGED	EGGS		YOUNG FLEDGED
	LAID	HATCHED		LAID	HATCHED	
1987	4	4	4	—	—	—
1988	4	3	3	4	4	4
1989	5	5	3	4	4	4
Total	13	12	10	8	8	8
Average	4.3	4.0	3.3	4.0	4.0	4.0
Percent	100.0	92.3	76.9	100.0	100.0	100.0

the vicinity of the nest, the male and the female again hunted cooperatively (32 of 38 observations). The parents then brought prey either to the nest or to the ledge on which the young were perched. After the young had fledged and were capable of flying some distance they accompanied their parents on hunting forays, but only one nestling at a time (70 observations). Young that did not participate remained on ledges in the vicinity of the nesting ledge. Following dispersal of the young, the male and the female remained in their territory, but hunted and fed separately.

Both males were less successful (Table 2) at hunting than their mates (48.9% and 43.3% compared to 58.7% and 47.1% respectively). Except for the western male, the falcons were least successful during the summer when hunting alone. Cooperative hunting between mates enhanced hunting success and was greatest prior to the breeding season. Females had greater success than males (Mann-Whitney U test, $P < 0.05$; Table 2) when cooperatively hunting with young. The overall hunting success of 49.1% is high compared to other *Falco* (e.g., Bird and Aubry 1982, Dekker 1987).

Nest Defense. Most territorial birds defend territories only against their own kind, but some also exclude other species with similar ecology. Some species defend only their nesting sites (Newton 1979). At the nest, Lanner Falcons attacked and drove away larger raptors such as Rough-legged Hawks (*Buteo lagopus*) and Golden Eagles (*Aquila chrysaetos*), but other falcons that nested in the vicinity, kestrels (*Falco tinnunculus*) and Barbary Falcons (*Falco pelegrinoides*), were not attacked. The two pairs of Lanner Falcons seemed to have 'mutually exclusive feeding territories' (Newton 1979).

Breeding Success. Both pairs laid eggs in scrapes on a cliff ledge (see also Brown et al. 1982). Clutches were completed toward the end of February and young hatched in the third or fourth week of March. The young fledged towards the end of April and dispersed from the parents' territory in mid-June.

In the 1987 breeding season, the western female laid 4 eggs, one each at 24 hr intervals. In the 1988 breeding season, the nest was observed when the first young started to hatch. The next day three young had hatched, indicating that young can hatch within 24 hours of each other and that incubation was penultimate or even ante-penultimate (Kridelbaugh 1983). This does not concur with Brown et al. (1982) who state that incubation begins with the first or second egg.

On three occasions I observed young dismember Rock Doves (190–290 g) at the age of 26 d (3 observations). At this age they hopped about the cliff face during the day, often occupying different ledges. Toward sundown, however, they congregated on the nesting ledge. After the young could fly short distances, they kept in vocal contact with each other and usually flew towards the parent with food. At approximately 60 d of age they accompanied their parents on hunting forays.

Reproductive success by the falcons is reported in Table 3. Average clutch size for both pairs was 4.2. Each of the pairs raised only one brood. The overall hatching success for both pairs during the five pair-years was 95.2% and is higher than the 71% found by Brown et al. (1982). Total fledging success was 78.3%. Pairs returned to nest on the same ledges in subsequent years.

Based on my study area, I cannot concur with the conclusions of Brown et al. (1982) and Osborne and

Colebrook-Robjent (1984) that Lanner Falcon nesting density is mainly dependent upon nest site availability. Nesting ledges similar to those used by the pairs studied were widely available and hence this factor was unlikely to limit density. I believe that other limiting factors, are yet to be discovered.

ACKNOWLEDGMENTS

I thank Burt Kotler, Oren Hasson, David Ward and Tom Grubb, Jr. for valuable comments on the manuscript. Dick Dekker, and T. Osborne helped in further improvement.

LITERATURE CITED

- ANONYMOUS. 1977. Map of the world distribution of arid lands. MAB, Technical Note 7. UNESCO, Paris, France.
- BIRD, D.M. AND Y. AUBRY. 1982. Reproductive and hunting behavior in Peregrine Falcons in Southern Quebec. *Can. Field-Nat.* 96:167-171.
- BROWN, L. 1970. African birds of prey. Collins Publ. Co., London, U.K.
- BROWN, L.H., E.K. URBAN AND K.B. NEWMAN. 1982. The birds of Africa. Academic Press, London, U.K.
- CADE, T.J. 1982. The falcons of the world. Collins Publ. Co., London, U.K.
- CRAMP, S. AND K.E.L. SIMMONS. 1980. Handbook of the birds of Europe, the Middle East and North Africa. The birds of the Western Palearctic. (Vol. II). Hawks to Bustards. Oxford University Press, U.K.
- DEKKER, D. 1987. Peregrine falcon predation on ducks in Alberta and British Columbia. *J. Wildl. Manage.* 51: 156-159.
- FRUMKIN, R. 1986. The status of breeding raptors in Israeli deserts, 1980-85. *Sandgrouse* 8:42-57.
- HECTOR, D.P. 1986. Cooperative hunting and its relationship to foraging success and prey size in an avian predator. *Ethology* 73:247-257.
- KRIDEBAUGH, A. 1983. Nesting ecology of the Loggerhead Shrike in central Missouri. *Wilson Bull.* 95: 303-309.
- NEWTON, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD.
- OSBORNE, T.O. AND J.F.R. COLEBROOK-ROBJENT. 1984. Observations on the Lanner Falcon in Eastern Zambia In J.M. Mendelsohn and C.W. Sapsford [EDS.], Proceedings of the 2nd symposium of African Predatory Birds. Natal Bird Club, Durban, S. Africa.
- SALVO, G. 1984. Primi dati sulla biologia del lanario, *Falco biarmicus*, nella Sicilia Centro-Meridionale. *Riv. Ital. Orn., Milano* 54:244-248.
- THOMSETT, S. 1987. Bat hunting by Lanner Falcons in Kenya. *Gabar* 2:7-8.
- TOUT, P. 1986. Kestrel regularly catching bats. *Br. Birds* 79:431-432.
- VAN JAARSVELD, J. 1988. African goshawks and European hobbies bat-hawking. *Gabar* 3:29-31.
- YOSEF, R. 1988. Kleptoparasitism in birds of prey. *Torgos* 7:67-77.

Received 25 September 1990; accepted 11 March 1991

DO MIGRANT SWAINSON'S HAWKS FAST *En Route* TO ARGENTINA?

JOHN S. KIRKLEY

*Division of Math and Science, Western Montana College of the University of Montana,
Dillon, MT 59725*

ABSTRACT.—Some observers assert that Swainson's Hawks (*Buteo swainsoni*) do not feed during their migration between North America and Argentina, which lasts 5 or more weeks. Evidence for such a prolonged fast is anecdotal, speculative, and equivocal. A migratory fast of this duration is physiologically and ecologically improbable. It is doubtful that Swainson's Hawks can accomplish fattening of the magnitude necessary for this prolonged fast. Approximately half of the birds have little visible subcutaneous fat when they reach Panama, only about the halfway point of their journey. Although fasting migrants would incur a negative water balance and would need to drink periodically, observations of drinking during migration appear to be lacking. It seems improbable that a highly insectivorous raptor would reject food for a period of 5 weeks or more while traveling through regions which support some of the richest invertebrate faunas in the world; the adaptive value of such a behavior is not apparent.

¿Se abstienen de comer las rapaces migratorias de la especie *Buteo swainsoni* en su ruta a la Argentina?

EXTRACTO.—Algunos observadores sostienen que las aguilillas de la especie *Buteo swainsoni* no comen durante su migración desde Norte América a la Argentina, que puede durar 5 ó más semanas. Evidencias para tan prolongado ayuno son anecdoticas, especulativas y equívocas. Un ayuno migratorio de esta duración es fisiológica y ecológicamente improbable. Es dudoso que estas aves *Buteo swainsoni* puedan lograr un nutrimento de la necesaria magnitud para este prolongado ayuno. Aproximadamente la mitad de las aves tienen muy poca grasa subcutánea visible cuando ellas llegan a Panamá, que está aproximadamente en el punto medio de su travesía. Aun cuando los migrantes incurrieran en un balance negativo de agua y necesitaran beber periódicamente se observa que falta, al parecer, el hecho de beber durante la migración. Parece improbable que raptoras que son altamente insectívoras, omitan comer por un período de 5 ó más semanas, mientras viajan a través de regiones que ofrecen una de las más ricas faunas invertebradas del mundo. El valor que se adapte a tal conducta no es aparente.

[Traducción de Eudoxio Paredes-Ruiz]

The question of whether a particular avian species can meet its energy needs during long distance migration by relying on stored body fat, or by refueling (i.e., feeding) is intriguing. Remarkable examples of premigratory fattening and fasting migration have been documented in a number of avian species, which make long, nonstop flights over oceans, deserts or other inhospitable areas where refueling is difficult or impossible. Other migratory species migrate more slowly, alternating daily periods of movement with periodic rest stops. They typically feed *en route* as they encounter feeding opportunities.

Most migrant raptors use this “stop and go” migration pattern. Slower migrants may maintain somewhat elevated levels of stored body fat during migration, but this moderate fat depot appears to serve mainly as a reserve supply to carry them through periods of food scarcity. They do not store enough premigratory fat to fuel the entire migration. A re-

fueling strategy spares the use of this reserve supply of fat and may augment the fat depot when the migrant finds sufficient food supplies along the way (Berthold 1975).

Several workers have hypothesized that some neotropical raptors (e.g., Turkey Vultures *Cathartes aura*, Swainson's Hawks *Buteo swainsoni* and Broad-winged Hawks *Buteo platypterus*) fast during migration (Smith 1980, 1985, Smith et al. 1986, Houston 1987, 1990). These raptors often fly in large, concentrated flocks (kettles) between their north temperate breeding grounds and their non-breeding areas mainly in Central America or South America. The selective advantage of fasting migration (i.e., total abstention from feeding for prolonged periods) is not intuitively obvious. The stop and go pattern of migration should make refueling possible, unlike non-stop marathons where fasting is obligatory.

This commentary reexamines the evidence for

fasting migration in Swainson's Hawks. It critiques the energetic arguments previously used to support the hypothesis, considers the water budget constraints on migration, and examines the ecological plausibility of fasting migration in this species.

The Fasting Migration Hypothesis. Brown and Amadon (1968) reported the "general lore" that these species of raptors do not feed during migration. Smith (1980) presented the following evidence to support the fasting hypothesis: 1) the scarcity of published accounts of migrants seen feeding, 2) the reports from country people in Panama of both Swainson's and Broad-winged Hawks in weak condition on the ground below roosts and similar reports of exhausted Swainson's Hawks in Argentina, and 3) the absence of feces and pellets below roosts where thousands of the hawks had roosted the previous evening. Smith (1980) states that "most of the evidence is circumstantial, but, in total, supports the fasting hypothesis." Smith has argued that the massed flights and huge communal roosts would likely preclude most individuals from obtaining significant amounts of food under such crowded conditions, and that it would be more costly to forage and feed than to fast.

Smith (1985) elaborated on the scenario of an "anorexic migration strategy" by speculating that Swainson's Hawks feed copiously while wandering south in small groups, then cease feeding at about 30°N latitude when they begin massed flights. Smith (1985) estimated that the fasting migration lasted 50–60 d, based on the dates of passage of the first observed massed flocks at Las Cruces, New Mexico and Panama City and the time of arrival of Swainson's Hawks in Argentina. The duration of fasting migration was later revised downward to 37.5 d by assuming that a hawk averages 240 km/day throughout the 9000 km journey (Smith et al. 1986). A key assumption in their fasting migration hypothesis is that thermal soaring is a highly efficient mode of travel with very low energetic costs, only twice the basal metabolic rate.

Weaknesses in the Fasting Migration Hypothesis. The circumstantial evidence for prolonged fasting can be refuted in several ways. Concentrations of hundreds of migrating Swainson's Hawks have been observed as far north as Saskatchewan (Houston 1987, 1990), Washington and Montana (Bent 1937). These locations are 1500–2000 km north of the presumed extent of massed migration and would apparently add at least another week of travel to the required duration of fasting, assuming the rationale

that massed flights preclude feeding. Smith (1985) acknowledged some published accounts of Swainson's Hawks feeding in large groups in Texas (Littlefield 1973) and in Costa Rica (Slud 1964). Large assemblages of Swainson's Hawks also have been seen feeding in Washington and California (Bent 1937), Idaho (Johnson et al. 1987), and near Veracruz, Mexico (M. Ramos, pers. comm.).

Although mass roosts of these migrant hawks in Panama are reported to lack feces, feces were present at mass roosting sites of migrant hawks in Arizona (Henshaw 1875 in Bent 1937) and in Mexico (M. Ramos, pers. comm.). It is possible that during the first hours of light each day, before thermal soaring is feasible, most hawks disperse from roosts, regurgitate pellets and then feed mainly on insects. Most of the resulting excrement from that early morning meal would be eliminated during the following 10-hour flight period. Rates of food passage through the gastrointestinal tracts of raptors have not been determined, but judging from the rates of food passage in other avian species, it is reasonable to assume that a Swainson's Hawk would eliminate the bulk of an early morning meal before arriving at the evening roost (G. Duke, pers. comm.). If hawks have virtually emptied their gastrointestinal tracts before they enter an evening roost, little fecal or pellet material should be found beneath an infrequently used roost.

Reports of southbound hawks arriving in a weakened condition in Panamanian roosts (Smith 1980) suggest that some hawks become undernourished when they reach maximally crowded conditions in the geographical bottleneck of the Central American isthmus. However, undernutrition could be due to poor foraging success, rather than absolute fasting. The presence of emaciated migrant Swainson's Hawks in Central America indicates that some hawks deplete their limited energy stores much earlier than should be the case according to the fasting migration hypothesis. Indeed, the observation of emaciated Swainson's Hawks in Panama supports the alternative hypothesis that migrant hawks typically carry only moderate fat reserves which may be seriously depleted if the birds fail to find sufficient nourishment along the way.

Problems with the Predicted Duration of Fasting. The speculation that hawks fast for 5–8 wk during migration is a major weakness of the fasting hypothesis. Could a hawk, even at rest, survive such a long period of food deprivation? Using Smith's

(1980) original estimates of migration duration (60 d) and Swainson's Hawk lean body mass (900–1000 g), approximately 420–450 g of stored fat would be required for standard metabolism (SMR) alone (Aschoff and Pohl 1970). This fat depot would constitute 45–47% of the original body mass. In this computation, the fat has not been included as metabolically active tissue.

The required amount of fat storage would have to be even larger than the above estimate, because a bird in migratory flight should require more energy than a bird at rest (e.g., 2 × SMR; Baudinette and Schmidt-Nielsen 1974), and a soaring bird carrying such a heavy burden of body fat should expend more energy per distance traveled than a bird at its optimal flight mass.

Smith's (1980) original estimate of Swainson's Hawk body masses (900–1000 g) is similar to the body masses determined by Craighead and Craighead (1956) ($\delta = 908$ g; $\varphi = 1069$ g), Fitzner (1978) ($\delta = 747$ g; $\varphi = 1080$ g), and Smith et al. (1986) ($\delta = 723$ g; $\varphi = 966$ g). These data indicate that females average about 160–260 g heavier than males. In later publications Smith (1985) and Smith et al. (1986) arbitrarily select a lean body mass of 600 g for male Swainson's Hawks, a seemingly low estimate, to compute the energy cost of migration. They did not attempt to model the energetics of females which reportedly weigh 900–1000 g.

Smith (1985) stated that if the lean body mass of a Swainson's Hawk is 600 g and its fat mass is 240 g "it could easily make the flight between Argentina and southern North America in 60 days without feeding." Smith's estimate, which assumes the catabolism of 4 g of fat per d (or 159 kJ/d; assuming that fat averages 39.7 kJ/g), would only supply 77% of the energy required for standard metabolism of a non-passerine bird of that body mass (Aschoff and Pohl 1970), or 88% of the estimated resting metabolism of a diurnal raptor of that size (Wasser 1986). Smith's (1985) metabolic estimate is far below that which would reasonably be expected for a bird in active migration.

Using a computer modeling technique, Smith et al. (1986) offered a revised estimate indicating that a male Swainson's Hawk (lean body mass = 600 g) would catabolize approximately 8.8 g of fat per day or 330 g of fat for a 9000 km flight. In the model, they assumed that the energy cost of flight is only twice the basal metabolic rate, roosting metabolism is 80% of standard metabolism, and migration speed averages 240 km/d (a 37.5 d journey). Furthermore,

they contended that the storage of such a large fat depot (55% of the lean mass) is "physiologically reasonable" (Smith et al. 1986).

Problems with the Necessary Amount of Stored Fat. The implausibility of a large raptor storing enough fat to sustain a fasting migratory journey lasting many weeks is another major weakness of the fasting migration hypothesis. It is doubtful whether Swainson's Hawks can accomplish fattening of the magnitude necessary for this prolonged fast. An exhaustive study of the body composition of 688 migrant Goshawks (*Accipiter gentilis*) in Sweden showed maximum fat levels of 14.1% and 17.2% of body mass in males and females, respectively (Marcstrom and Kenward 1980). Gessaman (1979) reported premigratory fat levels in American Kestrels (*Falco sparverius*) averaging 5–7% of the total body mass.

Little is known about the size of fat deposits of most diurnal raptors, but workers have frequently assumed that substantial differences in the average body masses of adults at different times of the year represent changes mainly in the amount of stored fat. The greatest body mass fluctuations in adult raptors have been recorded as the measured differences in body mass of females in egg laying condition versus non-breeding condition. Newton (1979) described the "great increase" in the mass of female European Sparrowhawks (*Accipiter nisus*) from a prelaying average of 300 g to an average at the peak of laying of 345 g, an increase of 15%. Similarly, female American Kestrels average approximately 29% heavier during the laying period in May than during July, the month of their lowest average mass of 109 g (J.S. Kirkley, unpubl. data). Extreme levels of premigratory fattening (30–47%) have been found only among small birds which make long, nonstop flights; the average fat reserves of even the larger limicolous birds (i.e., sandpipers and plovers) do not exceed more than 20% of the live mass (Berthold 1975).

The limited information on raptor body mass fluctuations does not support the contention that male Swainson's Hawks can store fat equal to 55% of their lean mass or 35% of their total body mass. Female Swainson's Hawks would require proportionately similar increases in their body masses, because their 160–260 g larger body masses should, according to allometric predictions, require the catabolism of at least 17–23% more fat than is needed for males. Smith et al. (1986) assumed that the additional energetic costs of carrying these large bur-

dens of body fat would be taken into account by using total body mass rather than lean mass in the allometric equations for estimating energy expenditures. Whether this allowance actually overestimates the true rate of energy expenditure, as Smith et al. (1986) contend, remains an unanswered question.

Quantitative measurements of stored fat in Swainson's Hawks are lacking. Smith et al. (1986) estimated the relative fatness of southbound hawks captured from mass roosts in Panama by inspecting their visible subcutaneous fat. The investigators judged only 8% (5 of 64) of the Swainson's Hawks to be very fat (fat index = 3), whereas 41% of the juveniles and 51% of the adults had little or no visible fat (fat index = 1 or 0). Low subcutaneous fat indices in a migrant should indicate that body fat is nearly depleted, because subcutaneous fat is considered to be the last region of body fat to be utilized (Blem 1989).

These fat index data pose a serious objection to the fasting migration scenario. Nearly half of the hawks examined had practically exhausted their fuel supply at slightly less than the halfway point of their hypothetical 9000 km fasting journey. Swainson's Hawks, at that point, should be carrying more than half of the original fat depot (at least 165 g of fat in males, or 28% of their lean body mass). A hawk (600 g lean mass) possessing over 165 g of fat should certainly have sufficient subcutaneous fat to be visually judged "very fat." In contrast, only 8% of the Swainson's Hawks were judged to be "very fat." These data alone refute the idea that most Swainson's Hawks fast for the entire duration of migration.

Water Budget Considerations. The respiratory water losses of fasting migratory birds should exceed their rates of metabolic water production; this negative water balance will be even more severe if substantial cutaneous water losses occur (Hart and Berger 1972). An estimated rate of fat oxidation of 8.8 g/d (Smith et al. 1986) would yield 9.4 g of water, assuming oxidation of one gram of fat yields 1.071 g of water (Schmidt-Nielsen 1964:30). The estimated minimum rate of evaporative water loss of a resting 600 g hawk would be approximately 18.3 g/d (Crawford and Lasiewski 1968, equation 6). The calculated minimum water deficit would, therefore, be approximately 9 g/d (1.5% of lean body mass). This value probably underestimates the daily water deficit of a fasting hawk, because rates of evaporative water loss should increase with the higher rates of pulmonary ventilation expected to accompany elevated metabolism during flight. Higher rates

of cutaneous evaporation should also result from increased convection during flight. The magnitude of the water budget deficit would increase even further if there were any excretory water losses or if fasting hawks ever had to pant to cool themselves in the high temperatures and intense sunlight of those subtropical and equatorial regions.

Basal rates of evaporative water loss would, alone, amount to more than 10% of a fasting hawk's lean body mass per week. With the likely routes of additional water loss, a fasting migrant hawk probably would need to drink, each week, a quantity of water equal to 15–20% of its lean body mass to offset its water deficit. Normally, raptors do not drink water, because they obtain sufficient water from the prey they consume (Bartholomew and Cade 1963). If the fasting migration hypothesis were valid, massed flocks of fasting hawks should be seen occasionally drinking at open water (undoubtedly a memorable spectacle), yet I have not read or heard of such behavior. Lack of evidence of drinking lends support to the contention that migrating hawks must be maintaining their water balance by feeding *en route*.

Ecological Considerations. A final argument against the fasting migration hypothesis is the one that seems most obvious from an ecological standpoint. Prolonged fasting migration is only typical of birds which fly nonstop over inhospitable barriers such as deserts or bodies of water. What is the ecological barrier posed by the migration route of Swainson's Hawks? Apparently none. Like many species of gulls, Swainson's Hawks are known to congregate on the ground in large flocks and to gorge themselves on grasshoppers, crickets and other insects (Bent 1937, Johnson et al. 1987). Are the flocks of Swainson's Hawks always so large as to preclude them from exploiting insects they encounter throughout the 9000 km journey? It is difficult to imagine that Swainson's Hawks would terminate all feeding during those many weeks of travel through the tropics and subtropics, particularly since those areas are rich in insect abundance. In conclusion, there appears to be no obvious ecological necessity for prolonged fasting by any of the raptors migrating through the Neotropics.

Insects should be especially abundant during the southward passage of hawks in October, because this is the tropical rainy season with its accompanying resurgence of vegetation and insect life. Rainstorms lasting several days are not uncommon in the subtropics of Mexico and Central America, and these storms are known to effectively ground Swainson's

and Broad-winged Hawks (M. Ramos, pers. comm.). When thermal soaring migration of these hawks is delayed, as it is on rainy days and during the first hours of light each morning, the hawks should be expected to disperse from their roosts and hunt for food.

Speculations which attempt to extrapolate the behavior of southbound Swainson's Hawks in Panama to their entire 9000 km journey may lead to erroneous conclusions. Questionable energetic parameters may add overly optimistic support for the plausibility of fasting migration. Further studies are needed which actually document the behavior of members of individual flocks for several consecutive weeks. These studies should include continuous monitoring of massed flocks as they move through Mexico, Central America and South America. Predicted behavior, based on the considerations presented in this commentary, would include opportunistic feeding by hawks when they are not involved in thermal soaring, and no drinking. Periods of fasting or undernourishment, should be short-term, and feeding should commence when insect infestations and other prey are opportunistically encountered.

ACKNOWLEDGMENTS

I wish to express my thanks to Western Montana College of the University of Montana for financial support enabling me to present this commentary at the Joint Meeting of the Raptor Research Foundation and the ICBP World Working Group of Birds of Prey in Veracruz, Mexico in October 1989. I appreciate the insights I gained through conversations with Dr. Mario Ramos, Dr. Gary Duke and other colleagues. The manuscript was greatly improved by the critical reviews of Dr. Marc Bechard, Dr. James Gessaman, Dr. C. Stuart Houston, and Dr. Neal Smith, to whom I am greatly indebted.

LITERATURE CITED

- ASCHOFF, J. AND H. POHL. 1970. Rhythmic variations in energy metabolism. *Proceedings, Fed. Amer. Soc. Expt. Biol.* 29:1541-1552.
- BARTHOLOMEW, G.A. AND T.J. CADE. 1963. The water economy of land birds. *Auk* 80:504-539.
- BAUDINETTE, R.V. AND K. SCHMIDT-NIELSEN. 1974. Energy cost of gliding flight in Herring Gulls. *Nature* 248:83-84.
- BENT, A.C. 1937. Life histories of North American birds of prey. Part 1. U.S. Natl. Mus. Bull. 167.
- BERTHOLD, P. 1975. Migration: control and metabolic physiology. Pages 77-128 in D.S. Farner and J.R. King [Eds.], *Avian biology*. Vol. 5. Academic Press, New York.
- BLEM, C.R. 1989. Avian energy storage. Pages 59-113 in R.F. Johnston [Ed.], *Current ornithology*. Vol. 7. Plenum Press, New York.
- BROWN, L.H. AND D. AMADON. 1968. *Eagles, hawks and falcons of the world*. McGraw-Hill Co., New York.
- CRAIGHEAD, F.C. AND J.J. CRAIGHEAD. 1956. *Hawks, owls and wildlife*. Stackpole Co., Harrisburg, PA.
- CRAWFORD, E.C., JR. AND R.C. LASIEWSKI. 1968. Oxygen consumption and respiratory evaporation of the Emu and the Rhea. *Condor* 70:333-339.
- FITZNER, R.E. 1978. Behavioral ecology of the Swainson's Hawk (*Buteo swainsoni*) in southeastern Washington. Ph.D. thesis, Washington State University, Pullman, WA.
- GESSAMAN, J.A. 1979. Premigratory fat in the American Kestrel. *Wilson Bull.* 91:625-626.
- HART, J.S. AND M. BERGER. 1972. Energetics, water economy and temperature regulation during flight. *Proc. 15th Int. Ornithol. Congr.*, pages 189-199.
- HOUSTON, C.S. 1987. Migration of Saskatchewan Swainson's Hawks. Abstract. *Western Raptor Migration Symposium*. Boise, ID.
- . 1990. Saskatchewan Swainson's Hawks. *American Birds* 44(2):215-220.
- JOHNSON, C.G., L.A. NICKERSON AND M.J. BECHARD. 1987. Grasshopper consumption and summer flocks of non-breeding Swainson's Hawks. *Condor* 89:676-678.
- LITTLEFIELD, C.D. 1973. Swainson's Hawks preying on fall army worms. *Southwestern Naturalist* 17:433.
- MARCSTROM, V. AND R. KENWARD. 1980. Sexual and seasonal variation in condition and survival of Swedish Goshawks *Accipiter gentilis*. *Ibis* 123:311-327.
- NEWTON, I. 1979. *Population ecology of raptors*. Buteo Books, Vermillion, SD.
- SCHMIDT-NIELSEN, K. 1964. *Desert animals: physiological problems of heat and water*. Clarendon Press, Oxford, U.K.
- SLUD, P. 1964. The birds of Costa Rica. *Bull. Amer. Mus. Nat. Hist.* 128:1-430.
- SMITH, N.G. 1980. Hawk and vulture migrations in the Neotropics. Pages 51-65 in A. Keast and E.S. Morton [Eds.], *Migrant birds in the Neotropics: ecology, behavior, distribution and conservation*. Smithsonian Inst. Press, Washington, DC.
- . 1985. Some uncertain aspects of migration by Swainson's Hawks (*Buteo swainsoni*) and Turkey Vultures (*Cathartes aura*). *Proc. North American Hawk Migration Conf.*, Rochester, NY.
- , D.L. GOLDSTEIN AND G.A. BARTHOLOMEW. 1986. Is long-distance migration possible for soaring hawks using only stored fat? *Auk* 103:607-611.
- WASSER, J.S. 1986. The relationship of energetics of falconiform birds to body mass and climate. *Condor* 88: 57-62.

Received 14 January 1991; accepted 2 April 1991

SHORT COMMUNICATIONS

RESPONSE TO KIRKLEY

DAVID L. GOLDSTEIN

*Department of Biological Sciences, Wright State University,
Dayton, OH 45435*

NEAL G. SMITH

*Smithsonian Tropical Research Institute, Apartado 2072,
Panama, Republic of Panama*

Smith (1980, 1985), and later Smith et al. (1986), presented the hypothesis that some raptors (Swainson's Hawks, *Buteo swainsoni*, and Broad-winged Hawks, *Buteo platypterus*, in particular) might fast during portions of their soaring migration, and we considered the question of whether these birds could store sufficient energy to fuel long-distance soaring. Kirkley has reconsidered several of the arguments presented by Smith et al. (1986) and concludes that fasting is unlikely. These reconsiderations involve questions of energetics, water balance, and ecology. Each of these points deserves some discussion.

Smith et al. (1986) noted that no feces were found under trees where mass roosts of migrant hawks spent the night. Kirkley suggests that perhaps the hawks feed in early morning and completely eliminate their feces prior to roosting. This seems a reasonable and testable hypothesis. It might be substantiated, for example, by observations of early morning feeding by large flocks of migrant Swainson's or Broad-winged Hawks. At present, we are unaware of reports of such feeding bouts.

The energetics model presented by Smith et al. (1986) examined the mass of fat that would be required to fuel flights of different durations. What would be the migration range based on a reasonable mass of stored fat? We concluded that "... migration by the hawks without feeding from the southern U.S. to northern South America would require deposition of fat amounting to 20–25% of lean body mass. Although such fat deposition has not been recorded for raptors, this is within the range commonly measured in migratory birds of other taxa (and so) our calculations suggest that a long-distance fasting migration is physiologically reasonable." According to the model, deposition of this mass of fat would fuel a migrating Swainson's Hawk for approximately 2.5 wk and 4000–4500 km. Kirkley sets up something of a straw man in his argument, choosing to focus on flights of longer distance (9000 km) and duration (up to six weeks). Although we calculated that such a prolonged fasting migration would require greater than 50% mass gain as premigratory fat, we never suggested that the hawks actually accomplish this level of

fattening. We might also note that measurements of pre-migratory fat deposition in large birds with migratory strategies like Swainson's and Broad-winged Hawks are simply unavailable.

Kirkley also argues that negative water balance would preclude a fasting migration. It is generally acknowledged that metabolic water will rarely match evaporative water losses in birds, and only a few small species, mostly desert-adapted birds, can survive on a dry diet (Bartholomew 1972). One might therefore expect a fasting hawk to lose body mass from a water deficit. Nevertheless, this argument does not preclude a prolonged fast. First, several large birds, including species of geese and penguins, do endure prolonged fasts (Cherel et al. 1988). Second, Kirkley has based his calculations on rates of evaporation measured on normally hydrated birds under conditions of low humidity in the laboratory. Evaporative water loss is reduced in high humidity environments (Lasiewski et al. 1966, Webster and King 1987), and can also be physiologically modified in water-stressed birds (Arad et al. 1987). Thus, the ambient and physiological conditions during migration may affect rates of evaporation. Actual measures of physiological condition of migrating hawks, such as permeability of the skin to water vapor, plasma and urine osmotic concentrations, or plasma concentrations of anti-diuretic hormone, might elucidate the physiological condition of these birds with respect to water balance.

Finally, Kirkley argues that it just doesn't make sense for the birds to fast as they cross the insect-rich tropics and sub-tropics, and again he argues in terms of a six week, 9000 km flight. In contrast, we have suggested that it might be difficult for an individual bird to procure a substantial meal among a dense crowd of conspecifics. First, Broad-winged Hawks are not highly insectivorous. Second, the migratory passages of Broad-winged and Swainson's Hawks are quite highly circumscribed, suggesting that individuals do not drop out to feed for any extended period. It is not obvious that insects, or other prey, would be easily available to dense concentrations of these large birds, especially in forested regions. Finally,

and again, we did not suggest that the fast persists for so long as Kirkley implies.

An overriding impression one receives from this set of arguments is that much of our understanding of the migration strategy of Swainson's and Broad-winged Hawks remains conjectural. What is the appropriate lean body mass? How much pre-migratory fat is deposited? Do the hawks eat or drink *en route*? What is the physiological condition of the birds at different stages of migration? What were the historical evolutionary forces that promoted the strategy of mass migration? Kirkley has not provided data bearing on any of these points. We believe that the available data remain consistent with the hypothesis of a fasting migration for some substantial portion of the flight of Swainson's Hawks and Broad-winged Hawks. However, this certainly remains a hypothesis, and only data collected from pre-migratory and migratory birds will provide evidence for or against it.

RESUMEN.—Kirkley considera que los gavilanes de las especies *Buteo platypterus* y *B. swainsoni* no pueden llevar reserva de grasa, ni pueden tolerar la pérdida de agua para migrar en ayunas, como lo propone Smith et al. (1986), y que por tanto deben alimentarse. Sin embargo, la migración con vuelo de remonte obliga a estas aves a volar en grandes bandadas, lo que les limita el poder alimentarse. La aparente abundancia de alimentos disponibles para estas aves rapaces, excepto en condiciones de abundancia temporal, no ha sido observada. Consideramos que nuestras sugerencias, en cuanto a la migración en ayunas durante una distancia de 4000–5000 km y tal vez más, son razonables. Pese a la importancia de este tópico, aún no se tiene concreta información acerca de la reserva de grasa y agua en estas aves durante su migración.

LITERATURE CITED

- ARAD, Z., I. GAVRIAELI-LEVIN, U. EYLATH AND J. MAR-
DER. 1987. Effect of dehydration on cutaneous water
evaporation in heat-exposed pigeons (*Columba livia*).
Phys. Zool. 60:623–630.
- BARTHOLOMEW, G.A. 1972. The water economy of seed-
eating birds that survive without drinking. Proc. 15th
Int. Ornithol. Congr., pages 237–254.
- CHEREL, Y., J.-P. ROBIN AND Y. LEMAHO. 1988. Phys-
iology and biochemistry of long-term fasting in birds.
Can. J. Zool. 66:159–166.
- LASIEWSKI, R.C., A.L. ACOSTA AND M.H. BERNSTEIN.
1966. Evaporative water loss in birds—I. Charac-
teristics of the open flow method of determination, and
their relation to estimates of thermoregulatory ability.
Comp. Biochem. Physiol. 19:445–457.
- SMITH, N.G. 1980. Hawk and vulture migrations in the
Neotropics. Pages 51–65 in A. Keast and E.S. Morton
[EDS.], *Migrant birds in the Neotropics: ecology, be-
havior, distribution and conservation*. Smithsonian Inst.
Press, Washington, DC.
- . 1985. Some uncertain aspects of migration by
Swainson's Hawks (*Buteo swainsoni*) and Turkey Vul-
tures (*Cathartes aura*). Proc. North American Hawk
Migration Conf., Rochester, New York.
- , D.L. GOLDSTEIN AND G.A. BARTHOLOMEW.
1986. Is long-distance migration possible for soaring
hawks using only stored fat? *Auk* 103:607–611.
- WEBSTER, M.D. AND J.R. KING. 1987. Temperature
and humidity dynamics of cutaneous and respiratory
evaporation in pigeons, *Columba livia*. *J. Comp. Phys.*
157:253–260.

Received 18 March 1991; accepted 2 April 1991

J. Raptor Res. 25(3):88–89

© 1991 The Raptor Research Foundation, Inc.

THREE POSSIBLE NEST-RELIEF FACTORS IN THE AMERICAN KESTREL (*Falco sparverius*)

JUAN ESTEBAN MARTÍNEZ-GÓMEZ

Av. 16 de Septiembre 1758, Veracruz, Veracruz 91900, Mexico

Balgooyen (1976) reported that male American Kestrels during incubation typically visited nests twice a day, once in the morning and once in the afternoon, and suggested that the male seemed to dictate the time of nest-relief. Olendorff (1968) could not predict nest-relief in kestrels because most of the times when the male presented himself,

the female did not come out of the nest box. Although I noted a pattern of nest-relief behavior similar to that described by both Roest (1957) and Balgooyen (1976), I twice saw a female replace the male by entering the cavity. Here I report some cues that may influence nest-relief behavior in kestrels.

Table 1. Number of instances of incubating kestrels according to time of day in central Wisconsin, 1990. Sample sizes are in parentheses.

H	NUMBER OF FEMALES (71)	NUMBER OF MALES (40)	TOTAL (111)
0301–0330	1	0	1
0331–0400	1	0	1
0401–0430	0	0	0
0431–0500	2	1	3
0501–0530	1	0	1
0531–0600	6	5	11
0601–0630	1	9	10
0631–0700	11	3	14
0701–0730	3	5	8
0731–0800	11	1	12
0801–0830	3	0	3
0831–0900	4	2	6
0901–0930	4	0	4
0931–1000	1	0	1
...			
1201–1230	0	1	1
1231–1300	0	0	0
1301–1330	1	0	1
1331–1400	0	1	1
1401–1430	1	0	1
1431–1500	3	4	7
1501–1530	6	2	8
1531–1600	3	6	9
1601–1630	4	0	4
1631–1700	2	0	2
1701–1730	1	0	1
1731–1800	0	0	0
1801–1830	1	0	1

During the 1990 breeding season on the Buena Vista Marsh in Portage County, Wisconsin, I noticed that on 14, 17 and 20 May, eight male American Kestrels (three, two and three, respectively) were incubating at almost the same time, 0600 H. Wilmers et al. (1985) found in West Virginia and Pennsylvania males incubating principally ≤ 2.8 hr before sunset, but in Quebec males were incubating "more uniformly among several periods." From 30 April to 15 June I frequently found males incubating at about 0600 H and 1500 H during weekly visits to 21 occupied nest boxes in the study area (Table 1). I found

males in 40 of 111 checks (36%); 17 were in the first 10 days after the clutch was completed, 8 in the second 10 days, 13 in the third 10 days, and only 2 after the 30th day, but this could be a bias due to the timing of sampling.

From 17 May to 21 June, I watched 8 pairs of kestrels from 0500 to 0700 H and from 1400 to 1600 H in 31 sessions, totaling 62 hr of observation. In 12 instances the male took his place in the box during the session, in 6 the male had done so before the session, and in 13, I saw no nest-relief. Thus, in 52% of the sessions I found males incubating. Males took their place in the nest box in 16 of 20 sessions (80%) when the sun was visible. In contrast, they did so in only 2 of 11 sessions (18%) on heavily overcast days. Balgooyen (1976) found "that temperatures above 21°C allow a rather lax rate of nest-relief but exchange is prompt at temperatures below 10°C." My field notes show that nest-relief occurred in 11 of 18 sessions (61%) with temperatures below 21°C and in 7 of 13 sessions (53%) with temperatures above 21°C. Although I watched pairs in a similar stage of incubation certain pairs of birds were more predictable than others in their patterns of nest-relief.

RESUMEN.—Se reporta una notable incidencia de Halcones Cernícalo macho (*Falco sparverius*) incubando alrededor de las 0700 H y las 1500 H; así como la posible influencia de la temperatura e iluminación ambientales, y el estadio de incubación en este fenómeno.

ACKNOWLEDGMENTS

I am grateful to Frances Hamerstrom and Annie Wendt for their advice.

LITERATURE CITED

- BALGOOYEN, T.G. 1976. Behavior and ecology of the American Kestrel (*Falco sparverius*) in the Sierra Nevada of California. *Univ. Calif. Publ. Zool.* 103:1–87.
 OLENDORFF, R.R. 1968. A contribution to the breeding behavior of the American Kestrel in captivity. *Raptor Res. News* 2(4):77–92.
 ROEST, A.I. 1957. Notes on the American sparrow hawk. *Auk* 74:1–19.
 WILMERS, T.J., R. BOWMAN AND D.E. SAMUEL. 1985. Notes on incubation by male kestrels in West Virginia, Pennsylvania, and Southern Quebec. *N. Amer. Bird Band.* 10(1):6–8.

Received 21 August 1990; accepted 16 November 1990

INFLUENCE ON PELLET EGESTION TIME IN INDIVIDUAL GREAT HORNED OWLS ALLOWED TO VIEW EGESTION IN OTHER OWLS

GARY E. DUKE AND ORAL A. EVANSON

Department of Veterinary Biology, University of Minnesota, St. Paul, MN 55108

SUSAN B. CHAPLIN

Department of Biology, University of St. Thomas, St. Paul, MN 55105

When a raptor, or other carnivorous bird, eats the whole body of its prey, it must then deal with the indigestible fur or feathers and bones of that prey item. Raptors typically deal with these wastes by forming them into a pellet in their stomach (gizzard) and egesting the pellet orally (Duke 1985). For several years, research in our laboratory has concentrated on, first the mechanism, and then the regulation, of the egestion process. Regulation has been studied by determining meal to pellet intervals (MPI) with various diets and feeding schedules. In strigiforms, MPI is directly related to meal size (Duke et al. 1976), to the nature of the meal (Duke and Rhoades 1977) and to feeding schedules (Fuller and Duke 1979).

These previous investigations of MPI in owls did not consider the possible influence of subjects being housed together (in view of each other) on digestion time. It was assumed for these investigations, however, that such influences probably would have been less than influences imposed by other aspects of the protocol such as changes in diet or feeding schedules. Therefore, the only objective of the present study was to examine whether MPI may be altered when Great Horned Owls (*Bubo virginianus*) are placed in view of each other. We hypothesized that because this species is typically not social (except during breeding), the presence of other individuals may affect digestion time.

Three healthy, but permanently crippled Great Horned Owls, obtained from the rehabilitation clinic at The Raptor Center, University of Minnesota, were used. They were males weighing 1070–1230 g, respectively, and were trained to eat 65–75 g of fresh-frozen thawed mice between 1000–1015 H daily. The owls were weighed weekly to monitor their health; all maintained, or slightly gained body weight.

Experiments were performed in two identical animal holding rooms between 1 April to 20 October 1990. Lights were automatically turned on in these rooms from 0800–2200 H daily and temperature and relative humidity were maintained at 20–22°C and 45–50%, respectively. Access to the rooms was limited to three individuals who regularly fed the birds and maintained the rooms. Chambers in which owls were kept and automatic egestion timing devices have been previously described (Duke et al. 1976, 1980).

The order of experiments and arrangement of owls was: Room 1, Owl #1 alone; Room 1, Owl #1 facing Owl #2; Room 1, Owl #1 facing Owls #2 and #3; Room 1, Owl #2 facing Owl #3 (#1 removed); and simultaneously in Room 1, Owl #2 alone and in Room 2 Owl #3 alone. Thus, each owl was tested alone and with one or two other owls for 30–40 d in each situation and 25–40 pellets were collected from each owl in each situation. The influence of housing treatment and time of exposure to that treatment on MPI were examined by split-plot analysis of variance (Snedecor and Cochran 1980). Where the ANOVA was significant, comparison of means was performed using Tukey's test (0.05 level). Generally, MPI data for the first 5–7 d of the treatment were not used because owls did not eat the entire meal. Only 20 d of data were entered into the ANOVA, the maximum number of levels of comparison for the program.

The mean MPI for Owl #1 alone was significantly longer ($P < 0.0001$) than its MPIs when it was with other owls (Table 1). The mean MPI for Owl #2 when alone was significantly shorter ($P < 0.002$) than its MPIs when it was with other owls. The MPIs for Owl #3 were not significantly affected ($P < 0.176$) by being with other owls (Table 1). The different response of each owl to each situation was also evident as a significant ($P = 0.0001$) interaction between treatments and birds shown in the analysis of variance. Statistical analysis further indicated that MPIs obtained when these birds were together were significantly different than MPIs obtained from single birds or from two birds housed together ($P = 0.0001$). Lastly, there was no significant change in MPI over time in any of the situations ($P = 0.626$), MPIs apparently changed almost immediately when housing situations were changed.

We had hypothesized that four possible responses could occur when owls were housed with other owls versus when they were kept alone: 1) MPI may become shorter when housed with other owls. This would be a suitable response if an owl "wanted" to digest a meal, egest a pellet and have an empty stomach so it could set off to hunt before other owls. This would be a competitive response. 2) MPI could become longer due to the stress of association with other owls. Because Great Horned Owls are usually solitary, such associations could be stressful. Stress, involving

adrenergic responses, would slow digestion. 3) Owls might synchronize their rates of digestion and have similar MPIs. This response would benefit the group rather than the individual as in response number one. 4) Owls may have no response to being housed with other owls. Again the group would benefit because no individual would be disadvantaged or gain an advantage.

MPI in Owl #1 shortened in response to being with other owls as proposed in hypothesis 1. MPI in Owl #2, however, was lengthened in response to other owls (hypothesis 2) and MPI was unaffected in Owl #3 in response to other owls (hypothesis 4). Thus, while the response was varied between these three owls, it appears that in laboratory studies, housing owls together may significantly affect their digestion and thus, their MPI. Future research on factors affecting MPI and perhaps other physiologic processes must take this possibility into account. Whether free-flying owls similarly affect each other is unknown.

RESUMEN.—Anteriores estudios concluyen que el intervalo entre la ingestión de alimento y la emisión de ega-grópila (MPI) en buhos, está relacionado con la cantidad y la naturaleza de la comida ingerida, así como de las horas del día en que ocurre la ingestión. Sin embargo, la posible influencia en el MPI de la presencia de individuos a la vista el uno del otro, todavía no ha sido investigada. Cuando tres buhos de la especie *Bubo virginianus* fueron mantenidos solos, o en compañía de uno o dos más, el intervalo fue acortado en un buho, alargado en otro y mantenido igual en el tercero. Estos posibles efectos deben ser considerados en la conducción de estudios de laboratorio con buhos de esta especie.

[Traducción de Eudoxio Paredes-Ruiz]

LITERATURE CITED

DUKE, G.E. 1985. Raptor physiology. Pages 225–231 in M.E. Fowler [ED.], *Zoo and wild animal medicine*. Saunders Pub. Co., Philadelphia, PA.

Table 1. Mean (\pm SD) meal-to-pellet intervals in hours for three Great-horned Owls (*Bubo virginianus*) housed with or without other owls.¹

OWL No.	TREATMENT		
	ALONE	WITH 1 OWL	WITH 2 OWLS
1	17.04 ² \pm 0.71	16.37 ³ \pm 1.91	14.69 ⁴ \pm 0.65
2	14.39 ² \pm 0.85	15.75 ³ \pm 1.32	14.99 ⁴ \pm 0.94
3	17.69 \pm 1.90	17.68 \pm 1.14	17.01 \pm 1.01

¹ n = 20 d.

^{2,3,4} Means in the same row with different superscripts are significantly different ($P < 0.05$).

_____, O.A. EVANSON AND A.A. JEGERS. 1976. Meal to pellet intervals in 14 species of captive raptors. *Comp Biochem. Physiol.* 53A:1–6.

_____, M.R. FULLER, AND B.J. HUBERTY. 1980. The influence of hunger on meal to pellet intervals in Barred Owls. *Comp. Biochem. Physiol.* 66A:203–207.

_____, AND D.D. RHOADES. 1977. Factors affecting meal to pellet intervals in Great-horned Owls (*Bubo virginianus*). *Comp. Biochem. Physiol.* 56A:283–286.

FULLER, M.R. AND G.E. DUKE. 1979. Regulation of pellet egestion: the effects of multiple feedings on meal to pellet intervals in Great-horned Owls. *Comp. Biochem. Physiol.* 62A:439–444.

SNEDECOR, G.W. AND W.G. COCHRANE. 1980. Statistical methods. Iowa State University Press, Ames, IA.

Received 22 December 1990; accepted 2 April 1991

DIURNAL BODY TEMPERATURE CYCLE IN THE NORTHERN HAWK-OWL (*Surnia ulula*)

CHARLES T. COLLINS

Department of Biology, California State University, Long Beach, CA 90840

The general topic of body temperatures in birds has been reviewed by Wetmore (1921), Baldwin and Kendeigh (1932) and most recently by Dawson and Hudson (1970). Their work has shown that body temperature depends on activity level, thermal stress (Chaplin et al. 1984, Dawson and Hudson 1970), nutritional state (Chaplin et al. 1984), and body size (McNabb 1966). Time of day may also be important since body temperatures can be from 1–8°C higher during the waking phase of a bird's daily cycle even when inactive (King and Farner 1961, Dawson and Hudson 1970). Most species of owls which have been considered to date show the reversed diel cycle, with highest body temperatures at night, typical of nocturnal species (Trost 1963, Siegfried et al. 1975, Wijnandts 1984). I report here data on the daily temperature cycle of the Northern Hawk-Owl (*Surnia ulula*), a diurnally active strigiform bird.

Body temperature (Tb) was measured on a single captive adult female Northern Hawk-Owl. All Tb were measured with a small bulb mercury thermometer. Readings were taken to the nearest 0.1°C with the bulb inserted approximately 11 mm into the cloaca (cloacal) or approximately 2.5 cm into the large intestine (core). Tb were recorded at the start of each hour throughout the day and night between February and April with at least 2 hr between readings. The owl was maintained at ambient indoor temperatures and local photoperiod on a weight maintaining diet.

A total of 109 cloacal Tb were obtained, 73 of which were daytime values (0800–1900 H) and 29 were nighttime values (2100–0600 H); an additional 7 values were obtained in the transition hours of 0700 and 2000 H. The overall mean Tb was $39.4^{\circ}\text{C} \pm 0.59$ SD (range 38.4–40.8). Mean daytime Tb was $39.6^{\circ}\text{C} \pm 0.42$ (38.4–40.8) and mean nighttime Tb was $38.8^{\circ}\text{C} \pm 0.24$ (38.4–39.5) (Fig. 1). The 0.78°C difference between mean daytime and mean nighttime Tb was statistically significant ($T = 8.67$, $P < 0.001$). A total of 64 core temperatures taken nearly simultaneously with the cloacal temperatures averaged $0.91^{\circ}\text{C} \pm 0.32$ higher. The cloacal and core Tb reported here are generally similar to those reported for a number of owl species (King and Farner 1961, Trost 1963, Dawson and Hudson 1970, McNabb 1966, Ligon 1969, Siegfried et al. 1975) but differences in measurement procedures preclude a more detailed comparison.

Several authors (Mikkola 1983, Johnsgard 1988, Huhtala et al. 1987) have reported that the Northern Hawk-Owl is typically active during the daylight hours as judged from observed prey captures and chick feeding bouts. Thus

the higher Tb recorded for this owl during the daytime is related to its diurnal activity phase as previously noted for an array of non-strigiform species (King and Farner 1961, Dawson and Hudson 1970). It has been suggested that endogenous factors may influence the timing of the diurnal temperature cycle in birds (Whittow 1976). However, the Tb of this owl seemed more directly related to its activity level than to the exact time of day. Similarly, hourly variation in Tb did not directly correspond to the daily pattern of change in ambient temperatures which generally increased more slowly throughout the morning, reached a distinct peak between 1400–1700 H, and gradually declined thereafter (Fig. 1).

A diel temperature cycle similar to that observed here for the Northern Hawk-Owl was noted in the Snowy Owl (*Nyctea scandiaca*; Siegfried et al. 1975) and Burrowing Owl (*Athene cunicularia*; Coulombe 1970), both of which are also diurnally active species. Gessaman (1978), however, failed to detect any diel cycle in the Snowy Owl in his subsequent study. A reversed cycle with higher nighttime Tb has been noted for the Barred Owl (*Strix varia*; Siegfried et al. 1975, Trost 1963), Long-eared Owl (*Asio otus*; Wijnandts 1984) and Barn Owl (*Tyto alba*; Trost 1963), three nocturnally active species. Great Horned Owls (*Bubo virginianus*) which are most active near dawn and dusk showed peak Tb at these times and lower Tb during both diurnal and nocturnal times of reduced activity (Siegfried et al. 1975, Chaplin et al. 1984).

There is a paucity of information on body temperature and its physiological correlates, heart rate and metabolism, for birds of prey, and owls in particular. Further work would clearly contribute to our overall understanding of the metabolic needs of these birds and its relationship to habitat management programs currently being formulated for them.

RESUMEN.—La temperatura corporal media (Tcm) de una lechuza hembra de la especie *Surnia ulula* fue de $39.4^{\circ}\text{C} \pm 0.59$ (DS). La Tcm diurna fue 0.78°C más alta que la Tcm nocturna, y la Tcm interna fue 0.91°C más alta que la Tcm cloacal. El ciclo diario en la Tcm estuvo vinculado con la fase activa diurna de esta lechuza, pero no tuvo relación aparente con factores endógenos.

LITERATURE CITED

- BALDWIN, S.P. AND S.C. KENDEIGH. 1932. Physiology of the temperature of birds. *Sci. Publ. Cleveland Mus. Nat. Hist.* 3:1–196.

Hawk-Owl Body Temperature

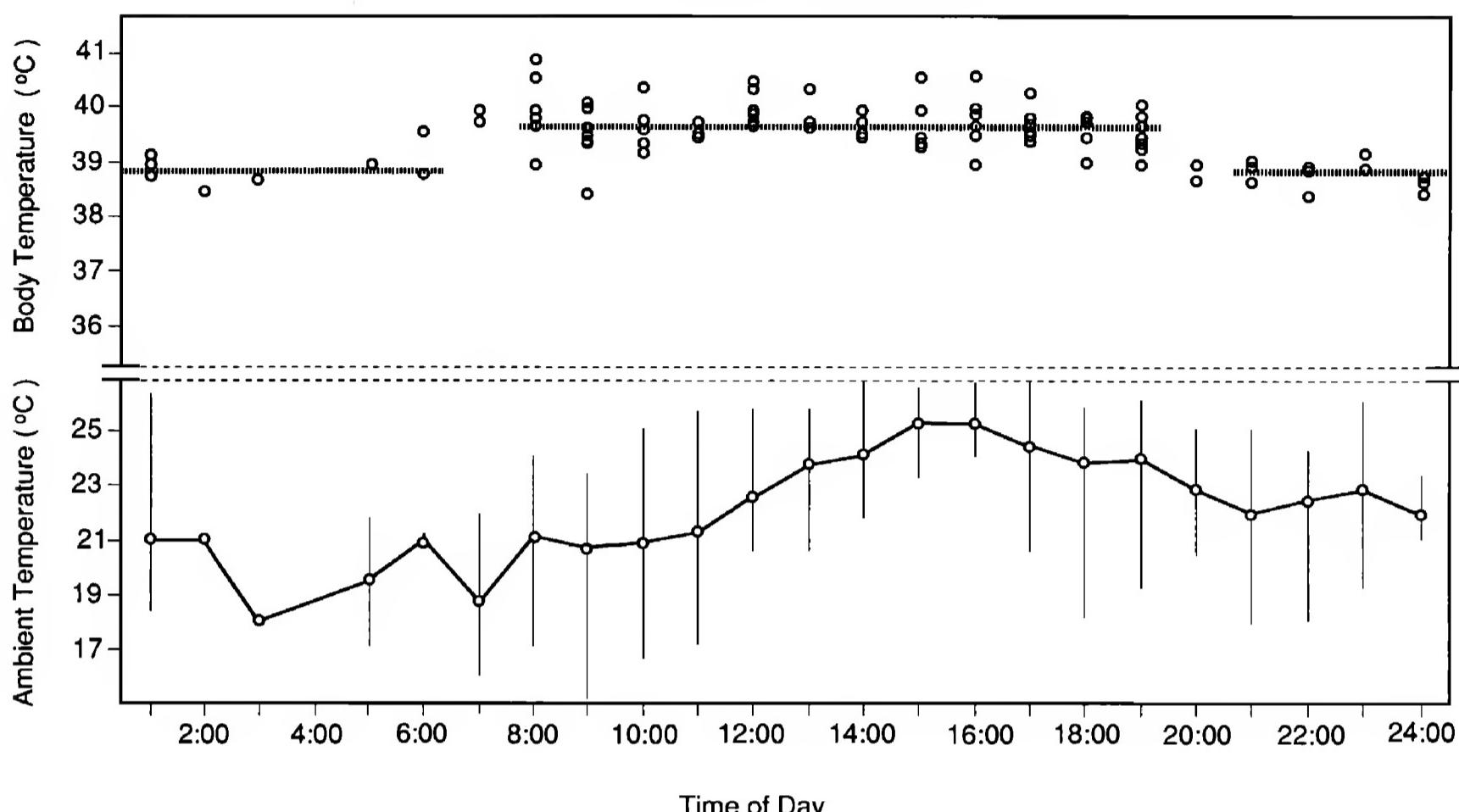


Figure 1. Ambient temperature and daily body temperature pattern for a captive Northern Hawk-Owl. Horizontal lines represent mean body temperature for nocturnal and diurnal portions of daily activity pattern.

- CHAPLIN, S.B., D.A. DIESEL AND J.A. KASPARIE. 1984. Body temperature regulation in Red-tailed Hawks and Great-horned Owls: responses to air temperature and food deprivation. *Condor* 86:175–181.
- COULOMBE, H.N. 1970. Physiological and physical aspects of temperature regulation in the Burrowing Owl (*Speotyto cunicularia*). *Comp. Biochem. Physiol.* 35:307–337.
- DAWSON, W.R. AND J.W. HUDSON. 1970. Birds. Pages 233–310 in G.C. Whittow [ED.], Comparative physiology of thermoregulation. Vol. 1. Invertebrates and non-mammalian vertebrates. Academic Press, New York.
- GESAMAN, J.A. 1978. Body temperature and heart rate of the Snowy Owl. *Condor* 80:243–245.
- HUHTALA, K., E. KORPIMÄKI AND E. PULLIAINEN. 1987. Foraging activity and growth of nestlings in the Hawk Owl: adaptive strategies under northern conditions. Pages 152–156 in R.W. Nero, R.J. Knapton and R.H. Hamre [Eds.], Biology and conservation of Northern Owls. USDA Forest Service Gen. Tech. Rept. RM-142.
- JOHNSGARD, P.A. 1988. North American owls. Smithsonian Institution Press, Washington, DC.
- KING, J.R. AND D.S. FARNER. 1961. Energy metabolism,

- thermoregulation and body temperature. Pages 215–288 in A.J. Marshall [ED.], Biology and comparative physiology of birds. Vol. 2. Academic Press, New York.
- LIGON, S.D. 1969. Some aspects of temperature relations in small owls. *Auk* 86:458–472.
- MCNABB, B.K. 1966. An analysis of the body temperatures of birds. *Condor* 68:47–55.
- MIKKOLA, H. 1983. Owls of Europe. Buteo Books, Vermillion, SD.
- SIEGFRIED, W.R., R.L. ABRAHAM AND V.B. KUECHLE. 1975. Daily temperature cycles in Barred, Great-horned and Snowy Owls. *Condor* 77:502–506.
- TROST, C.H. 1963. Body temperature variation in owls. M.S. thesis, University of Florida, Gainesville, FL.
- WETMORE, A. 1921. A study of body temperature of birds. *Smithsonian Miscellaneous Collections* 72(12):1–52.
- WHITTO, G.C. 1976. Regulation of body temperature. Pages 146–173 in P.D. Sturkie [ED.], Avian physiology. Springer-Verlag, New York.
- WIJNANDTS, H. 1984. Ecological energetics of the Long-eared Owl (*Asio otus*). *Ardea* 72:1–92.

Received 18 February 1991; accepted 31 May 1991

JUVENILE URBAN-HACKED PEREGRINE FALCONS (*Falco peregrinus*) HUNT AT NIGHT

ANNIE WENDT

Wisconsin Peregrine Society, P.O. Box 1148, Milwaukee, WI 53201-1148

GREG SEPTON

Milwaukee Public Museum, 800 W. Wells St., Milwaukee, WI 53233

JEFF MOLINE

1202 Country Club, Apt. 1, Santa Teresa, NM 88008

Although Peregrine Falcons (*Falco peregrinus*) are considered diurnal raptors, they have taken bats in the dim light of dawn and dusk (Stager 1941, Ratcliffe 1980). Beebe (1960) reported that Peale's peregrines (*F. p. pealei*) hunted nocturnal seabirds "so late in the evening, or so early in the morning, as to be almost nocturnal." Nelson (1970) found that peregrines nesting in murrelet colonies did not hunt during the day until most of the murrelets had moved offshore. Here we report nocturnal hunting by young peregrines released in Milwaukee, Wisconsin in 1987.

We released 14 captive-produced peregrines by hacking, described by Sherrod et al. (1982). The release site was on the top-floor ledge of the First Wisconsin Center, 178 m above street level. We colormarked the falcons with fluorescent paint and released five of them on 27 July, five on 6 August, and four on 9 August. We watched them from the "411 Building" located two blocks west, arriving each morning before first light and staying until dark.

We fed the falcons by tying *Coturnix* Quail (*Coturnix* spp.) to two hack boards: one board was attached to the hack box and the other to the roof of the 12-story Northwestern Mutual Life Insurance Building (NML) across the street and to the north. Every evening, after dark (about 2030–2100 H) from 27 July through the end of September, we removed the uneaten food and tied enough fresh quail to the boards to ensure that each falcon could eat its fill the next day. The falcons first started catching large, flying insects (i.e., dragonflies, butterflies) on 7 August and birds on 27 August. We saw them hunting downtown and along the shore of Lake Michigan, which is about four blocks east of the release site.

Several things suggested that the young peregrines were active at night. We often heard them calling as they flew past while it was still too dark for us to see. At daybreak, we found falcons on the NML roof, where none had been perched the night before. They often had full crops, or were just finishing a quail they had managed to remove from the hack board.

On at least six nights in August, we saw the peregrines flying at night. The Wisconsin Natural Gas Company Building (Gas Co.), across the street from the NML, has

many ledges and was a favored roosting place for the falcons both day and night. From dusk to midnight, spotlights mounted on the ledges point up against the brick walls, illuminating the building. As we left the NML after resupplying the hack boards, we could see as many as six peregrines at a time circling the Gas Co., chasing each other and darting about rather recklessly, lit from below by the spotlights.

We first found cached, night-killed prey on the "411" roof the morning of 8 September. Each night thereafter, we removed all prey remains before leaving the building. Each morning, before first light, we returned and found the bodies of birds that the falcons had cached on the 411, NML, and Gas Co. buildings. The falcons fed on these cached birds during the day, ignoring the quail on the hack boards. From 8–16 September we found a total of 38 Yellow-billed Cuckoos (*Coccyzus americanus*), one Black-billed Cuckoo (*C. erythrophthalmus*), and one Rose-breasted Grosbeak (*Pheucticus ludovicianus*), with a maximum of 13 birds on 13 September. Many of the cached birds had their bodies "raked" open or had their heads removed, both consistent with peregrine kills.

On 17 September, the weather changed abruptly from warm, sunny, and breezy, to cool and rainy for 1 wk. We found few new kills, and the falcons once again ate the quail we provided. Once the weather cleared after 22 September, the falcons stopped relying on the quail on a daily basis. We found an average of 1–2 new kills per day, and saw the falcons retrieving cached food from other buildings. By 29 September, all the falcons had stopped using the hack board and we closed the site for the season. Ten of the young falcons survived to independence; the other four were killed or crippled within 1 wk of release.

The falcons' increased hunting proficiency apparently corresponded with an influx of cuckoos into the area. The city lights probably encouraged the nocturnal hunting; D.M. Bird (pers. comm.) has seen American Kestrels (*F. sparverius*) hunting large, flying insects at night under the lights of Montreal's Olympic Stadium. It is possible that wild peregrines also take night-migrating birds, particularly when the moon is full.

RESUMEN.—Halcones Peregrinos (*Falco peregrinus*) jóvenes, que fueron sueltos en Milwaukee, Wisconsin en 1987, estuvieron activos y cazaron durante la noche. Desde el 8 al 16 de septiembre, encontramos 38 cuclillos de la especie *Coccyzus americanus*, 1 de la especie *C. erythrophthalmus*, y 1 picogordo de la especie *Pheucticus ludovicianus*, que habían sido cazados en la noche; con un máximo de 13 aves el día 13 de septiembre. Muchas de las aves capturadas tenían los cuerpos abiertos y decapitados, lo que es consistente en las víctimas de Halcones Peregrinos.

[Traducción de Eudoxio Paredes-Ruiz]

ACKNOWLEDGMENTS

We thank David Bird, Fran Hamerstrom, R. Wayne Nelson and Clayton White for reviewing this manuscript.

LITERATURE CITED

BEEBE, F.L. 1960. The marine peregrines of the Northwest Pacific Coast. *Condor* 62:145–189.

- NELSON, R.W. 1970. Some aspects of the breeding behavior of Peregrine Falcons on Langara Island, B.C. M.S. thesis, University of Calgary, Calgary, Alberta, Canada.
- RATCLIFFE, D.A. 1980. *The Peregrine Falcon*. Buteo Books, Vermillion, SD.
- SHERROD, S., W. HEINRICH, W. BURNHAM, J. BARCLAY AND T. CADE. 1982. Hacking: a method for releasing Peregrine Falcons and other birds of prey. The Peregrine Fund, Inc., Ithaca, NY.
- STAGER, K.E. 1941. A group of bat-eating Duck Hawks. *Condor* 43:137–139.

Received 30 November 1990; accepted 31 May 1991

LETTERS

BALD EAGLE ATTEMPTS TO INCUBATE BONE

Unique items have been found in Bald Eagle (*Haliaeetus leucocephalus*) nests during breeding including clothespins, clorox bottles, golf balls, gunny sacks, light bulbs, stones, duck decoys, a rubber rat, and items of human clothing including shoes, lace-trimmed panties, and a child's sleeper (M.J. Broley, 1952, *Eagle Man*, Pellegrini and Cudahy, New York, and J.B. Holt, pers. comm.). The use of these items by eagles to adorn the nest is presumably to indicate to other eagles that the nest is occupied (M.V. Stalmaster, 1987, *The Bald Eagle*, Universe Books, New York). However, there is no reference in the literature of Bald Eagles attempting to incubate any of these items. We report here on such an occurrence.

On 1 June 1988, while attempting to collect addled eggs from a Bald Eagle nest near Mullet Lake, in northcentral lower Michigan, we discovered an adult female Bald Eagle attempting to incubate a bone from a round steak of beef. An adult had been observed in an incubating position during an aerial Bald Eagle census by Michigan Department of Natural Resources wildlife biologists on 31 March 1988 (J. Weinrich, pers. comm.). Since an adult was observed to still be on the nest on 26 May 1988 (G.E. Matthews, pers. comm.), we decided to collect the eggs since the adult was evidently incubating them for a minimum of 62 days, 27 days past the latest expected hatching date.

The female eagle was in an incubating position when we approached the nest which was located in a 17 m Quaking Aspen (*Populus tremuloides*). When we were within 100 m of the nest tree, the female left the nest and did not attempt to defend it. The bone was within a mound of nesting material within the nest lining. There were no eggs, eggshell fragments or any other indication that eggs had been laid by this pair. The bone was collected from the nest so that the adult would stop incubation. The bone measured approximately 7.2 cm in diameter and approximately 2.0 cm in height with an open marrow cavity. This compares with Bald Eagle egg measurements that average 7.0–7.6 cm in length and 5.3–5.8 cm in width (M.V. Stalmaster, ibid.). An aerial survey of this breeding area on 2 June 1988 showed no eagles in the vicinity of the nest (J. Weinrich, pers. comm.).

This was probably the initial breeding attempt by this nesting pair. Adults from this breeding area, possibly the same pair, constructed a new nest 4 km from the 1988 nest and successfully raised two fledglings in 1989.

We would like to thank David Best, James Bruce, Timothy Kubiak, Glen Matthews, Sergej Postupalsky, William Robinson, and Jerome Weinrich for their assistance. We thank John Giesy and William Robinson for reviewing an earlier draft of this note and giving helpful comments. The Bald Eagle banding project was funded by the Michigan Department of Natural Resources, Natural Heritage Program-Nongame Wildlife Fund, USDI-Fish and Wildlife Service, and USDA-Forest Service.—**William W. Bowerman IV, Department of Biology, Northern Michigan University, Marquette, MI 49855; JOHN B. HOLT, Jr., 858 Johnson Street, North Andover, MA 01845.**

EGYPTIAN VULTURES STEAL FOOD FROM NESTLING GRIFFON VULTURES

Observations on food stealing were made in July 1980 at Los Arribes del Huebra, Salamanca, Spain. We observed an adult Egyptian Vulture (*Neophron percnopterus*) on a Griffon Vulture's (*Gyps fulvus*) nest. In the nest was a Griffon Vulture nestling, close to fledging. The Egyptian Vulture ate food on the ledge while the nestling was facing the wall in evasive attitude. The chick had its back to the Egyptian Vulture, and called as it did to its parents. The Egyptian Vulture moved to an adjacent Griffon Vulture's nest and took more food while a second adult Egyptian Vulture came to the first nest. Adult Griffon Vultures were absent.

Five similar observations, made at the raptor refuge of Montejo de la Vega, Segovia, Spain, have been reported to us by F.J. Fernández and F. Martínez (pers. comm.). In two occasions the Egyptian Vulture was expelled from the nest and, in one of them, the nestling did it in the same way as has been explained by F. Alvarez, L. Arias de Reyna and F. Hiraldo (1976, *Interactions among avian scavengers in southern Spain*. *Ornis Scand.* 7:215–226) in aggressive

interactions at carcasses. In all the cases the Egyptian Vultures were adults. Both species share the same breeding area in the studied regions, the Egyptian Vulture being more dispersed in them.

Kleptoparasitism might be an important source of food for Egyptian Vultures. However, it has only been observed late in the nestling period, when Griffon chicks are often left unattended by adults. Griffon nests are ten times more abundant than those of Egyptian Vultures in these areas, and so the effect on each Griffon nest is probably small.—**Juan Pascual, Adv. Ramon y Cajal, 85, 28016 Madrid, Spain. Jose M. Santiago, Departamento de Zoología, Facultad de Ciencias, Universidad Autónoma de Madrid, Cantoblanco, 28049 Madrid, Spain.**

J Raptor Res. 25(3):97

© 1991 The Raptor Research Foundation, Inc.

COMMON BARN OWL (*Tyto alba*) RELEASES EGG WHILE IN FLIGHT

While monitoring nest boxes built for owls in Kings County, California, Keith Locke and I witnessed the release of an egg while in flight by a Common Barn Owl (*Tyto alba*). On 14 March 1991, Locke and I checked nest boxes erected for Common Barn Owls. One box was mounted on an oak tree limb, approximately 6 m above ground, with a 30-cm metal pipe. Our visit to the box at 1601 h caused an adult Common Barn Owl to flush from within. During the owl's flight, I noticed what appeared to be a very large amount of excreta being eliminated by the owl over an open area of pasture approximately 15 m south of the box. On close examination Locke and I found that the excreta was in fact an egg which had been released while in flight. Locke and I collected what remains we could and left the site after counting an additional six eggs in the box.

Locke and I returned to the nest box on 22 and 29 March, and 5 April. The remaining eggs were cold to the touch at every visit and no adults were present. I can find no reference in the literature to the release of an egg while in flight of a Common Barn Owl.—**Douglas E. Trapp, P.O. Box 281, Hanford, CA 93232-0281.**

THESIS ABSTRACTS

FACTORS INFLUENCING BREEDING SUCCESS OF BALD EAGLES IN UPPER MICHIGAN

A study of factors responsible for poor population recovery rates of Bald Eagles (*Haliaeetus leucocephalus*) in the Upper Peninsula of Michigan was undertaken. The probable cause for low population growth rates on the Hiawatha National Forest is low chick production. This may result from removal of forage fish from inland lakes for sport fish management, human disturbance of nesting birds, and toxic contaminants. These factors were investigated in this study using the following methods: Bald Eagle productivity for breeding areas within 3.2 km of fish removals were compared spatially and temporally; foraging behavior was observed from blinds throughout the day, prey species were identified by observation of items carried to the nest and by collection of remains after fledging; concentrations of DDE, PCBs, and other organochlorine pesticides in blood plasma and mercury in feathers from nestling eagles were determined in order to relate contaminant exposure to nesting productivity; and White Suckers (*Catostomus commersoni*) and Bullheads (*Ictalurus* spp.) were stocked in winterkill lakes to determine if Bald Eagles would utilize a newly available food source.

Eagles in breeding areas where fish were removed for sport fish management (0.57 young per occupied nest) were significantly less productive than those breeding in areas where fish were not removed (1.30 young per occupied nest). The main food source of eagles was fish, with Northern Pike (*Esox lucius*) and Bullheads comprising 74% of all food items identified from prey remains. Hikers caused nesting eagles to become more aware or to take flight in four of four cases. Concentrations of PCBs and DDE from blood plasma from nestling eagles from breeding areas near the Great Lakes were significantly greater (PCB mean = 243 ppb; DDE mean = 147 ppb) than concentrations in plasma of nestlings from riverine breeding areas (PCB mean = 41 ppb; DDE mean = 19 ppb) and inland lake breeding areas (PCB mean = 27 ppb; DDE mean = 9 ppb). Bald Eagles and Osprey (*Pandion haliaetus*) fed on the fish stocked in the winterkill lakes but did not use this food source as much as that in naturally stocked lakes.

Results of this study strongly suggest that the factors most responsible for slow population recovery rates of Bald Eagles in the Upper Peninsula is poor chick production caused by removal of fish in interior breeding areas and by organochlorine contamination in breeding areas near the Great Lakes.—William W. Bowerman, IV. 1991. M.A. thesis, Department of Biology, Northern Michigan University, Marquette, MI 49855. Present address: Department of Fisheries and Wildlife, Pesticide Research Center, Institute for Environmental Toxicology, Michigan State University, East Lansing, MI 48824.

NESTING ECOLOGY AND NEST SITE HABITAT OF SHARP-SHINNED AND COOPER'S HAWKS IN MISSOURI

I located nesting accipiters throughout the forested areas of Missouri and determined reproductive parameters and nest site habitat characteristics. Seventeen Sharp-shinned Hawk nests and 43 Cooper's Hawk nests were located. Ninety-four percent of the Sharp-shinned Hawk nests occurred in pine stands. Seventy-seven percent of Cooper's Hawk nests occurred in pine stands and 23% were in oak-hickory stands. The reoccupancy rate of accipiter nest sites was 70%. Mean clutch size for Sharp-shinned and Cooper's Hawks was 4.5 and 3.7 eggs, respectively. The vegetative structure of pine stands selected by both species was similar but the structure of Sharp-shinned Hawk sites represents an earlier successional stage than those selected by Cooper's Hawks. Management for these species in pine should be directed toward providing stands with high percent canopy closure and basal area.—Kevin J. Kritz. 1989. M.Sc. thesis, School of Natural Resources, University of Missouri-Columbia, Columbia, MO 65211.

NEWS AND REVIEWS

Birds of prey in Virginia: a history of specimen records from 1853 to 1988 by David W. Johnston and William J. Ehmann. Virginia Avifauna No. 4, Virginia Society of Ornithology, Lynchburg, 1990, vi + 58 pp. Paper \$9.00 U.S.

Public and private natural history collections contain a wealth of data and biological materials. The objective of Johnston and Ehmann's monograph is to provide a comprehensive inventory of raptor specimens collected in the Commonwealth of Virginia. Specimens taken and preserved during the last 137 years in Virginia provide "snapshots" to reconstruct the biological and environmental history for geographic regions. The specimens and associated data allow a diverse set of questions to be addressed.

Traditionally, systematists have used collections as repositories for vouchering species and faunal descriptions. Maintaining the collection permits other scientists to re-examine the materials. The advent of techniques for DNA sequencing of museum specimens is an unprecedented asset for taxonomic classifications. In addition, population geneticists and conservation biologists can now identify which subspecies occurred in an area and characterize the genetics of the population. Environmental toxicologists can use historical specimens to identify background levels of contaminants prior to widespread distribution of the chemical. The impact of pesticides on egg shell thinning could not have been assessed without the availability of historic egg collections. Specimens and their data have been useful to ecologists in describing the natural history of raptors (e.g., range, molting, food habits and habitat). For extinct species, specimens are one of the few avenues left to reconstruct their ecology. Application of computer technology for information capture, retrieval, and visualization is improving the availability and utility of collections.

The authors provide a good description of the methods used in locating the specimens/records and compiling the inventory. In particular, they do an excellent job of explaining the difficulty in extracting precise information from historical records associated with specimens. Early specimens often contain vague descriptions of geographic locality, or have incomplete data (e.g., no date). Data were annotated accordingly if imprecise from the source.

The monograph contains two figures that support the text, and several pen-and-ink illustrations of raptors. The first figure is a map of Virginia with counties, cities, physiographic provinces, and miscellaneous features. Although the map is essential in interpreting the geographic descriptors used later in the text, it is difficult to use. The eastern part of the state is cluttered with names. Other features (refuges, parks, rivers, etc.) may be useful as references but only contribute to the difficulty in reading the map. The other figure is a histogram of the number of specimens taken each year between 1873 and 1988. It is easy to read and provides an interesting perspective on growth of collections. Large numbers of specimens were deposited in collections during the 1890s, 1910s, 1930s, and during the last 20 years. The first three pulses are thought to be birds taken specifically for building the collections, and the most recent period from bird-vehicle collisions.

The largest portion of the monograph is a table that lists all raptor specimens, organized by species and date. The data include (same order as the table): date collected, county or city of capture, age, sex, collection number, additional location information or reference, and disposition. Codes are used for the county/city, age, sex, collection, and disposition categories.

A small adjustment in the order of categories and the organization of information within categories would have made the table easier to use. The county/city column represents mixed spatial resolution and could have been split into two fields. County codes should be provided for all records where that information is available (city and county were exclusive in representation). Positionally, county/city codes should be adjacent to the location/reference field to provide a more logical flow of information. Although a geographic reference is provided when available, it is difficult to visualize the geographic distribution of specimens without drawing a map for each species. A small map of Virginia could have been easily prepared for each species with dots depicting specimen records. Citations throughout the monograph follow two different styles, which is quite distracting. Specimen type or disposition include eggs, skin, mounted, alcohol, or skeleton. An inventory of frozen tissue or blood from Virginian birds of prey would be a logical extension of the listing and consistent with current research efforts.

A discussion of the specimen inventory follows the table of specimens. Here, Johnston and Ehmann point out observable patterns and unusual occurrences from the specimens. Supplemental records that were discovered in the specimen search are also listed in this section. A summary after the discussion tallies the total number of specimens and supplemental records at nearly 2000 for Virginia. The literature cited section, which follows the summary, does not include all of the citations from the specimen and additional record listings. Two appendices end the monograph.

The first identifies the abbreviations for counties and cities, while the second lists collection abbreviations, curators, and collection addresses.

Compiling all of the specimens and records for a taxonomic group in a geographic area requires a tremendous amount of work. Johnston and Ehmann have provided the scientific community a valuable service in publishing their inventory, which is well worth the price. Not only does it greatly simplify locating necessary specimens in Virginia, but small collections that may have been lost or are at risk of deterioration and abandonment are back in the public arena. Historic specimens are irreplaceable and warrant a great deal of protection.—**Paul F. Steblein**

The **National Wildlife Rehabilitators Association** announces its small grants program. This program makes available two \$1,000 research grants in the field of wildlife rehabilitation. Each may be applied to one large project or several smaller research projects each totaling less than \$1,000.00. Applicants must demonstrate financial need and submit a typewritten proposal that includes: name(s) and resume of personnel involved, objectives of the project, a brief description of how the project will be carried out, a brief literature review and an itemized budget.

An annual report on progress is required. It is expected that those receiving NWRA support will present the results of their projects at an NWRA national meeting within 2 years of receipt of the grant.

The deadline for submitting proposals for research grants is *December 15* of each year. Recipients will be announced at the NWRA annual meeting in February and in writing.

The National Wildlife Rehabilitators Association also invites nominations for two awards. The **Lifetime Achievement Award** is given to an individual whose primary identification is with rehabilitation of wildlife and who has contributed to this field in a major way for many years. The **Significant Achievement Award** is for a person who has made a major contribution to the field within the last two years. Examples of such contributions would be the presentation of a research finding, or organization of a program, with a major theme in wildlife rehabilitation.

Each award consists of plaque, \$100, and free registration at the NWRA conference where the award will be presented. The deadline for submitting nominations for the awards is *December 15* of each year. Proposals and nominations should be sent to: **Mark Pokras, DVM, Tufts University School of Veterinary Medicine, Wildlife Clinic, 200 Westboro Road, North Grafton, MA 01536.**

Burrowing Owls have been banded and colormarked in Minnesota and South Dakota with standard U.S. Fish and Wildlife Service bands and green or yellow leg bands. Osprey and Peregrine Falcons have been banded in various midwestern states with U.S. Fish and Wildlife Service bands and a black leg band with a silver alpha-numeric code. Anyone sighting any of these birds please report the date, location, leg with color band and alpha-numeric code to the Bird Banding Lab, Laurel, MD 20708 and to **Mark Martell, The Raptor Center—University of Minnesota, 1920 Fitch Ave., St. Paul, MN 55108.**

The **1991 Raptor Research Foundation, Inc. elections** gave rise to two new and two re-elected directors. Our new directors are Tom Nicholls in the Central U.S. Region and Paul Steblein as Director at Large. Tom is with the U.S. Forest Service Lab at the University of Minnesota, and Paul is a scientist with the Biological Survey of the New York State Museum. Re-elected directors were Paul James as Canadian Director and Robert Kenward as Director at Large. Paul is Curator of Ornithology at the Saskatchewan Museum of Natural History in Regina. Robert Kenward is a researcher at the Institute of Terrestrial Ecology in Dorset, England. We extend our congratulations to these individuals.

Nearly 200 members voted which is an excellent response. Many thanks to them. Gary Duke, Chair, Nominating Committee.

THE RAPTOR RESEARCH FOUNDATION, INC.
(FOUNDED 1966)

OFFICERS

PRESIDENT: RICHARD J. CLARK
VICE-PRESIDENT: MICHAEL W. COLLOPY

SECRETARY: BETSY HANCOCK
TREASURER: JIM FITZPATRICK

BOARD OF DIRECTORS

EASTERN DIRECTOR: KEITH L. BILDSTEIN
CENTRAL DIRECTOR: PATRICK T. REDIG
MOUNTAIN & PACIFIC DIRECTOR:
STEPHEN W. HOFFMAN
EAST CANADA DIRECTOR: DAVID M. BIRD
WEST CANADA DIRECTOR: PAUL C. JAMES
INTERNATIONAL DIRECTOR #1:
FABIAN M. JAKSIC

INTERNATIONAL DIRECTOR #2:
EDUARDO E. IÑIGO-ELIAS
DIRECTOR AT LARGE #1: MICHAEL W. COLLOPY
DIRECTOR AT LARGE #2: ROBERT E. KENWARD
DIRECTOR AT LARGE #3: JEFFREY L. LINCOLN
DIRECTOR AT LARGE #5: JAMES A. GESSAMAN
DIRECTOR AT LARGE #6: GARY E. DUKE

EDITORIAL STAFF

EDITOR IN CHIEF: JOSEF K. SCHMUTZ, Department of Biology, University of Saskatchewan, Saskatoon, SK., Canada, S7N 0W0

ASSOCIATE EDITORS

KEITH L. BILDSTEIN
SUSAN B. CHAPLIN
CHARLES J. HENNY
C. STUART HOUSTON

ROBERT E. KENWARD
EUDOXIO PAREDES-RUIZ
PATRICIA P. RABENOLD
PATRICK T. REDIG

EDITOR OF RRF KETTLE: PAUL F. STEBLEIN

The *Journal of Raptor Research* is distributed quarterly to all current members. Original manuscripts dealing with the biology and conservation of diurnal and nocturnal birds of prey are welcomed from throughout the world, but must be written in English. Submissions can be in the form of research articles, letters to the editor, thesis abstracts and book reviews. Contributors should submit a typewritten original and three copies to the Editor. All submissions must be typewritten and double-spaced on one side of 215 by 280 mm (8½ x 11 in.) or standard international, white, bond paper, with 25 mm (1 in.) margins. The cover page should contain a title, the author's full name(s) and address(es). Name and address should be centered on the cover page. If the current address is different, indicate this via a footnote. Submit the current address on a separate page placed after the literature cited section. A short version of the title, not exceeding 35 characters, should be provided for a running head. An abstract of about 250 words should accompany all research articles on a separate page.

Tables, one to a page, should be double spaced throughout and be assigned consecutive Arabic numerals. Collect all figure legends on a separate page. Each illustration should be centered on a single page and be no smaller than final size and no larger than twice final size. The name of the author(s) and figure number, assigned consecutively using Arabic numerals, should be pencilled on the back of each figure.

Names for birds should follow the A.O.U. Checklist of North American Birds (6th ed., 1983) or another authoritative source for other regions. Subspecific identification should be cited only when pertinent to the material presented. Metric units should be used for all measurements. Use the 24-hour clock (e.g., 0830 H and 2030 H) and "continental" dating (e.g., 1 January 1990).

Refer to a recent issue of the journal for details in format. Explicit instructions and publication policy are outlined in "Information for contributors," *J. Raptor Res.*, Vol. 24(1-2), which is available from the editor.

1991 ANNUAL MEETING

The Raptor Research Foundation, Inc. 1991 annual meeting will be held on 6-10 November at the Westin Hotel in Tulsa, Oklahoma. Details about the meeting and a "call for papers," which invites 15 min presentations, posters and films, were mailed to Foundation members in June, and can be obtained from M. Alan Jenkins, Scientific Program Chairperson, G.M. Sutton Avian Research Center, P.O. Box 2007, Bartlesville, OK 74005; Tel. (918)336-2473, FAX (913)336-7783. For further information contact Ms. Keven Colbert, Local Committee Chairperson, G.M. Sutton Avian Research Center.

RAPTOR RESEARCH REPORTS

- #1, R.R. Olendorff. 1971. *Falconiform Reproduction: A Review Part 1. The Pre-nestling Period.* \$10.00 members, \$12.50 non-members.
- #2, F.N. Hamerstrom, B.E. Harrell and R.R. Olendorff [Editors]. 1974. *Management of Raptors. Proceedings of the Conference on Raptor Conservation Techniques, Fort Collins, CO, 22-24 March 1973.* \$10.00 members, \$12.50 non-members.
- #3, J.R. Murphy, C.M. White and B.E. Harrell [Editors]. 1975. *Population Status of Raptors. Proceedings of the Conference on Raptor Conservation Techniques, Fort Collins, CO, 22-24 March 1973. (Part 6).* \$10.00 members, \$12.50 non-members.
- #4, R.R. Olendorff, A. Miller and R. Lehman [Editors]. 1981. *Suggested Practices for Raptor Protection on Powerlines: State of the Art in 1981.* \$5.00 members, \$20.00 non-members.
- #5, S.E. Senner, C.M. White and J.R. Parrish [Editors]. 1986. *Raptor Research Conservation in the Next Fifty Years. Proceedings of a Conference held at Hawk Mountain Sanctuary, Kempton, PA, 14 October 1984.* \$3.50 members, \$4.50 non-members.
- #6, D.M. Bird, and R. Bowman [Editors]. 1987. *The Ancestral Kestrel. Proceedings of a Symposium on Kestrel Species, St. Louis, MO, 1 December 1983.* \$10.00 members, \$12.50 non-members.
- #7, R.R. Olendorff [Editor]. 1989. *The Raptor Research Foundation, Inc. Bibliographic Index (1967-1986).* \$2.50 members, \$5.00 non-members.
- #8, R.R. Olendorff, D.D. Bibles, M.T. Dean, J.R. Haugh and M.N. Kochert. 1989. *Raptor Habitat Management under the U.S. Bureau of Land Management Multiple-Use Mandate.* \$5.00 members, \$6.50 non-members.

Add \$2.50 for postage and handling, and \$1.00 each for additional reports.

BOOKS

- Biology and Management of Bald Eagles and Ospreys. Proceedings of the First International Symposium, Montreal, Canada.*
D.M. Bird [Editor]. 1983.
\$15.00 members, \$18.00 non-members plus \$5.00 shipping.

JOURNAL BACK ISSUES

Journal Back Issues are available. For details see page 73 of *the Kettle* or write: Jim Fitzpatrick, Treasurer, Raptor Research Foundation, Inc., Carpenter St. Croix Valley Nature Center, 12805 St. Croix Trail, Hastings, MN 55033.